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THE MACHINERY FOR PAYING OUT THE CABLE.

THE PUPIN TELEPHONE CABLE UNDER LAKE CONSTANCE.—[See page 248.]

THE MODERN AMERICAN BLAST FURNACE.*

THE PRACTICAL ASPECTS OF SMELTING.

BY BRADLEY STOUGHTON.

IN the modern blast furnace much attention has been paid to the various devices for handling material and charging the furnace. The object has been to save time, to keep the furnace working to full capacity, and to dispense with manual labor as far as possible.

Behind the blast furnace are situated two long rows of storage bins. These bins are filled by bottom-dumping railroad cars, which bring the ore to the furnaces, or by mechanical apparatus from the ore stored conveniently near. Between and under these two rows of bins runs a track on which little trains of ore buggies are transferred back and forth, being first filled with a weighed amount of ore, limestone, or fuel, and then switched into a position where they can deposit their contents into the loading skip of the blast furnace. In one of the big modern American furnaces, working at top speed the amount of material which must be dumped into the top during twenty-four hours will frequently exceed 2,000 tons, and the charging must go on for 365 days a year with never a delay of more than a few hours at a time.

In the modern type of furnace this loading is accomplished altogether by mechanism operated and controlled from the ground level, and no men are required to work at the top of the furnace. A double, inclined skipway extends above the top of the furnace. One skid discharges its load of ore, fuel, or flux into the hopper, while the second skip is at the bottom of the incline ready to be loaded with its charge. The upper hopper of the furnace is closed at the bottom by an iron cone, known as a "bell." This bell is pressed up against the bottom of the hopper by the lever of the counterweight, but may be lowered to allow the charge to fall into the true hopper of the blast furnace. In this way the true hopper is progressively filled with ore, flux, and fuel. This hopper is also closed at the bottom by a bell. The lowering of this bell is also controlled by mechanism operated from the ground level. At intervals this is effected, and the contents of the hopper allowed to fall in an annular stream distributing itself in a regular layer on top of the material already in the furnace and reaching to within a few feet of the bottom of the bell. As the upper bell is now held up against the bottom of the upper hopper, there is never a direct opening from the interior of the blast furnace to the outer air, so that the escape of gas, resulting formerly in the long flame rising from the top of the blast furnace whenever material was dropped into the interior, no longer occurs at our modern plants. This is not the only means of handling the raw material for the blast furnace, but the description given heretofore is illustrative of the general principles of labor-saving handling in connection with charging the blast furnace.

The blast furnace itself consists of a tall cylindrical stack lined with an acid (silicious) refractory firebrick. The hearth or crucible is the straight portion occupying the lower 8 feet of the furnace. Above that extends the widening portion, called the bosh, which reaches to that portion of the furnace having the greatest diameter. The stack extends throughout the remainder of the furnace, from the bosh to the throat. The brickwork of the hearth is cooled by causing water to trickle over the outside surface. Through the lining of the furnace, just at the top of the hearth, extend the tuyeres—eight to sixteen pipes having an internal diameter of 4 to 7 inches, through which hot blast is supplied. The "tuyere notches," or openings through which the tuyere pipes enter, as well as the tuyeres themselves, are surrounded by hollow bronze rings set in the brickwork, through which cold water is constantly flowing to protect them from being melted off at the inner ends. The number and size of the tuyeres are regulated in proportion to the diameter of the hearth, the volume and pressure of the blast, etc., so that the velocity of the blast shall distribute it as evenly as possible to the very center of the furnace. On the side of the furnace, and 30 to 40 inches below the level of the tuyeres, the "cinder notch" or "monkey" is situated. This is protected by a water-cooled casting, and the hole is closed by an iron plug, or bott. In the front, or breast, at the very bottom level of the crucible is the iron tap hole, from which all the liquid contents of the furnace can be completely drained. This is a large hole in the brickwork, and is closed with several balls of clay. The hottest part of the furnace is the bosh near the tuyeres and for a few feet above them. In order to protect the brick work of the bosh from this heat a number of hollow wedge-shaped castings are placed therein, through which cold water circulates. The brickwork is furthermore protected by a deposition of a layer of carbon, similar to lamp black, on its internal surface, covered by a layer of a sort of slag, replacing part of the brickwork. This deposition of carbon comes about through the reaction of the furnace operation itself. For the correct conduct of the smelter operation, and especially for the carrying off of the sulphur in the slag, it is necessary that a very powerful reduction influence must exist; this reducing influence is produced by an excess of coke and one of its results is the precipitation of finely divided carbon on the internal walls of the furnace. It is this thin layer of slag and carbon which is most effective in protecting the acid lining of the furnace from the corrosive action of the basic slag.

The air for smelting is driven into the furnace by blowing engines up to 2,500 horse-power each, and capable of compressing 50,000 to 65,000 cubic feet (4,875 pounds) of free air per minute to a pressure of 15 to 30 pounds per square inch, which is about what one furnace requires. It actually requires about four to five tons of air for each ton of iron produced in the furnace. After leaving the engines and before coming to the furnace the air is heated to a temperature of 800 to 1,200 deg. F. by being made to pass through the hot-blast stoves.

Each furnace is connected with four stoves. These are cylindrical tanks of steel about 110 feet high and 22 feet in diameter, containing two firebrick chambers. One of these chambers is open and the other is filled with a number of small flues. Gas and air are received in the bottom of the open chamber, in which they burn and rise. They then pass downward through the several flues, in the annular chamber surrounding the open chamber, and at the bottom pass out to the chimney as waste products. In passing through the stove they give up the greater part of their heat to the brickwork. After this phase is ended, the stove is ready to heat the blast. The blast from the blowing engine enters at the bottom of the flues, passes up through the outer chamber, down through the central chamber and to the furnace. In this passage it takes up the heat left in the brickwork by the burning gas and air. Sometimes there are three passes, instead of two, as described. In a blast furnace plant one stove is heating the blast while the other three are in the preparation stage, burning gas and air. By changing once an hour a pretty regular blast temperature is maintained. The gas used for the heating is the waste gas from the blast furnace itself, which amounts to about 90,000 cubic feet per minute at a temperature of 450 deg. F., and has a calorific power of about 85 to 95 B. T. U. per cubic foot. The latent and available heat of this gas is equivalent to approximately 50 per cent of that of the fuel charged into the furnace. Only about 30,000 cubic feet, or one-third of this gas, is needed for keeping the stoves hot, and the remaining two-thirds is used to produce power. If the stoves become clogged with dust, a larger amount of gas is required to keep up the temperature. The waste gas comes down the down-comer, settles out dirt in the dust catcher, and is then led to the stoves or the power producer. This gas varies in composition, but will average about 61 per cent nitrogen, 10 per cent to 17 per cent CO_2 and 22 per cent to 27 per cent CO. The latter can be burned with air to produce heat. If burned under boilers, the available gas will generate enough power to operate the blowing engines, hoisting mechanism, and other machinery used in connection with the furnace. At several plants the gas available for power is cleaned carefully and utilized in gas engines, whereby much more power is obtained, the excess over that necessary to furnish blast and the mechanical requirements of the furnace being usually converted into electricity and transmitted to more distant points.

The furnace is filled with alternate layers of fuel, flux, and ore, down to the top of the smelting zone. The exact location of this zone will be dependent upon the volume and pressure of blast, size of furnace, character of slag made, etc., but will extend from the level of the tuyeres to a few feet above them; that is, about to the top of the bosh. It will require perhaps fifteen hours for the material to descend from the top of the furnace to the smelting zone. During this descent, it is upheld partly by the resistance of the upward rushing column of hot gases, partly by its friction against the walls of the furnace, and partly by the loose column of smoke which extends through the smelting zone and to the bottom of the furnace and which alone resists melting in the intense heat of this zone. The blast, entering the furnace through the tuyeres, consists of 23 per cent by weight of oxygen, 77 per cent by weight of nitrogen, together with varying amounts of water vapor from moisture in the air.

As soon as the iron ore enters the top of the furnace, two reactions begin to take place between it and the ascending gases. (1) $2Fe_2O_3 + 8CO = 7CO_2 + 4Fe + C$. (2) $2Fe_2O_3 + CO = 2FeO + Fe_2O_3 + CO_2$. These reactions continue with increasing rapidity as the material becomes hotter. The carbon formed by reaction (1) deposits in a form similar to lamp-black on the outside and in the interstices of the ore. This reaction is, however, opposed by two reactions with carbon dioxide gas: (3) $Fe + CO_2 = FeO + CO$; (4) $C + CO_2 = 2CO$. Reaction (3) begins at a temperature of about 575 deg. F. which is met with about 3 or 4 feet below the top level of the stock, and (4) begins at about 1,000 deg. F., or 20 feet below the stock line. Reaction (4) is so rapid that the deposition of carbon ceases at a temperature of 1,100 deg.

All the way down the ore is constantly losing a proportion of its oxygen to the gases. At higher temperatures than 1,100 deg. F., FeO is stable and practically all of the Fe_2O_3 (or Fe_3O_4 if magnetite is being smelted) has been reduced. At 1,300 deg. F. solid carbon begins to reduce FeO. Practically all the iron is reduced to a spongy metallic form by the time the temperature of 1,475 deg. is reached. This is about 45 feet from the stock line and less than 30 feet above the tuyeres. At 1,475 deg. F. the limestone begins to be decomposed by the heat, and only CaO comes to the smelting zone. It is not supposed that these figures are exactly correct for the different levels, and it is probable that they change from day to day and from furnace to furnace. It will be seen that the upper 15 or 20 feet of the stock is a region of Fe_2O_3 and Fe_3O_4, gradually being converted to FeO by CO gas, and forming quantities of CO_2 gas. If these reactions are the only ones, the top gases would contain no CO, and have no calorific power, but reaction (1) produces both metallic iron and carbon, both of which reduce CO_2 and waste much energy as far as the blast furnace is concerned. Thus reaction (3) absorbs 2,340 calories, but wastes 68,040 calories, while (4) absorbs 38,880 calories.

From 20 to 35 feet below the stock line is the region of FeO, gradually being converted to metallic iron sponge by carbon. On the lower level of this zone the limestone loses its CO_2 which joins the other furnace gases. From 35 feet down to the smelting zone is the region of metallic iron. This spongy iron is impregnated with deposited carbon which probably to some extent soaks into it and dissolves as ink soaks into blotting paper. This carburization of the iron reduces its melting point and causes it to become liquid at a higher point above the tuyeres than it otherwise would.

On reaching the smelting zone the iron melts and trickles quickly down over the column of coke, from which it completes its saturation with carbon. At a corresponding point the lime unites with the coke ash and impurities in the iron ore, forming a fusible slag which also trickles down and collects in the hearth. It is during this transit that the different impurities are reduced by the carbon, and the extent of this reduction determines the characteristics of the pig iron, for in this operation, as in all smelting, reduced elements are dissolved by the metal while those in the oxidized form are dissolved by the slag. Only one exception occurs; namely, that iron will dissolve its own sulphide, FeS, and, to a less extent, that of manganese, MnS, but not that of other metals as, for instance, CaS.

There is always a large amount of silica present in the coke ash and some of this is reduced according to the reaction: $SiO_2 + 2C = Si + 2CO$. The extent of this reaction will depend on the length of time the iron takes to drop through the smelting zone, the relative intensity of the reducing influence and the avidity with which the slag takes up silica. A slag with a high melting point will trickle sluggishly through the smelting zone, and cause the iron to do the same to some extent, thus giving it more chance to take up silicon. A higher temperature in the smelting zone, which increases disproportionately the avidity of carbon for oxygen, will promote the reduction of silica. We can produce this higher temperature by supplying hotter blast. A larger proportion of coke to burden will further promote this reaction, because this not only increases the amount of the reducing agent, but also raises the temperature, and therefore the chemical activity of this agent. Thus the coke has both a physical and a chemical influence in increasing the intensity of the reduction in the smelting zone. A basic slag, because of its avidity for silica, will oppose the reduction of silica, and is one of the principal means of making low silicon pig iron. This is in spite of the fact that the basic slags are sluggish, and therefore trickle slowly through the smelting zone, thus

* Abstracted from the Engineering and Mining Journal.

exposing the silica longer to reducing influence, and also increasing the temperature of the materials in this zone by causing them to pass through it more slowly and absorb more heat, and by reducing the level of the smelting zone nearly to the tuyeres, which confines the intense temperature to the smaller area, or, in other words, diminishes the passage of heat upward.

Sulphur comes into the furnace chiefly in the coke. It is partly in the form of iron mono-sulphide, FeS, and partly in the form of iron pyrites, FeS_2, which loses one atom of sulphur near the top of the stock and becomes FeS, which will dissolve in the iron unless converted to sulphide of calcium, CaS. This is brought about according to the explanation of Prof. Howe, by the following reaction: $FeS + CaO + C = CaS + Fe + CO$. The CaS passes into the slag, and the odor of sulphur is very strong when the slag is running from the furnace. It is evident from this reaction that intense reduction, which increases the silicon in the iron, has the contrary effect on the sulphur, and this explains the common observation that iron high in silicon is liable to be low in sulphur. Indeed this relation is so constant as almost to be a rule. There are two exceptions, however: (1) Increasing the proportion of coke has a doubly strong influence in putting silicon in the iron; as regards sulphur, on the other hand, it has a self-contradictory effect; by increasing the amount of sulphur in the charge it tends to increase it in the iron, which is partly or wholly counteracted by its effect in the above reaction. (2) A basic slag may hold silicon from the iron, and it also holds sulphur from the iron by dissolving CaS more readily. In other respects the conditions which make for high silicon make also for low sulphur. Particularly is this true of a high temperature in the smelting zone, and the term "hot iron" has come to be synonymous in the minds of blast-furnace foremen with iron high in silicon and low in sulphur.

The amount of manganese in the iron is dependent, to a certain extent, upon the character of the ores charged, but it may be controlled somewhat by the character of slag made, because an acid slag will carry a large amount of manganese away in the form of silicate of manganese, $Mn\ SiO_3$.

With a certain unimportant qualification, the amount of phosphorus in the iron is controlled by the character of the ores charged, and districts or countries having high-phosphorus ores must make high-phosphorus irons. This is not an insuperable objection, because the presence of phosphorus, even up to 1.5 per cent, is desired in certain irons for foundry use, and the basic processes for making steel can remove this element.

The chemical influence of the blast furnace is a strongly reducing one and this is produced in order, first, to reduce the iron from the ore, second, to get rid of the sulphur, and third, to saturate the iron with carbon. Many attempts have been made to provide a process wherein the reducing influence was not so strong, and thus to produce a purer material than pig iron, because it is the intensity of the reduction which vitiates the iron with carbon and silicon. The great weakness of all such processes, however, is that they do not get rid of the sulphur, which is the most objectionable impurity that iron is liable to contain, and which is not satisfactorily removed by any process after once it makes its way into the iron. Finally, to saturate the iron with carbon renders the blast-furnace operation very much cheaper, because pure iron melts at a temperature much higher than can readily be obtained in the furnace, and melted iron is handled much more cheaply than it could be if allowed to solidify.

ORIGINAL RESEARCH.

ITS VALUE TO APPLIED SCIENCE.

IN a remarkable series of researches carried out some hundred years ago, Laplace, Fourier, and other mathematicians succeeded in showing that the solution of a vast assemblage of problems arising in every branch of natural science could be reduced to that of certain differential equations. They further showed that the latter could, in a large variety of special cases, be definitely solved in a finite form, and numerical results obtained. In the glare of the triumphs won by the astonishing ingenuity and indefatigable persistence of this distinguished band of mathematical physicists, there were not wanting prophets to predict that experimental philosophy had spoken almost its last word, and to welcome the dawn of an era when the cut-and-dry method of the laboratory should be entirely replaced by the pen of the mathematician and the logarithmic and other tables of the professional computer. Until the work of Laplace, a doubt existed as to whether the Newtonian law of universal gravitation was in itself sufficient, uncomplemented by other agency, to insure the permanent stability of the solar system, but, as he himself said in his famous reply to a comment of the great Napoleon, he did not in his "Mécanique Céleste" find the necessity arise for any supplementary hypothesis. A natural sequel was a widespread belief in the adequacy and generality of the so-called natural laws, a creed which received a notable extension by the triumph of Leverrier and Adams in locating the then unknown planet Neptune solely by the methods of mathematical analysis. The school which held an extreme view as to the possibilities of this latter method of research failed, however, to realize with adequate perspicuity the unquestionable fact that the answer to every mathematical problem is implicitly comprised in its original statement, and that if in any case the premises are incomplete, the final deduction will be equally deficient.

No one nowadays holds the belief that there is even a remote prospect of the mechanical or physical laboratory becoming obsolescent, though it cannot be disputed that certain matters are now settled by computation, as to which our predecessors sought guidance by direct experiment. No engineer now, for example, thinks of determining the sufficiency of the scantlings for a proposed bridge or girder by testing to destruction a model built to scale. It is found cheaper, quicker, and more elastic to settle such matters by computation; but though this is true, physical experiment has still to be relied on as providing the only reliable guidance as to the quality and suitability of the materials to be used. Concurrently, therefore, with notable advances on the application of mathematics to the solution of questions in mechanics and physics, there has been developed an even greater extension of facilities for the pursuit of experimental researches. Indeed, it is now universally recognized that the one method of investigating Nature is the indispensable complement of the other, and that if the mathematical physicist is merely beating the air in the absence of data derived from the laboratory, the experimentalist, lacking the assistance of the former to check the results of, and fix the direction of, his work, is in nearly as bad a plight.

Wide as has been the extension during recent years of opportunities for research, it cannot, we think, be claimed that the average quality of the work accomplished has experienced any corresponding enhancement. It is still from a few centers only, and these by no means the most lavishly endowed, that work of a really epoch-making character emanates. The two most striking chemical discoveries in recent years, for instance, have been the existence of inert gases in the atmosphere, and that of the radio-active bodies. Both of these were made in establishments which could in no way compare in the matter of lavishness of equipment and appointments with many of the great laboratories of Germany, for example.

In matters mechanical the laboratories of our technical schools, however serviceable they may have been in their purely educational aspect, have contributed singularly little in the way of really original contributions to the data of engineering. In England the shortness of the course is, no doubt, a serious handicap to the undertaking of very elaborate investigations, but with the four years' curriculum usual in America and on the Continent more might reasonably have been expected from the expensively equipped laboratories attached to the better-known schools of engineering there. As matters stand, pioneering work seems hardly to be attempted. Attention has been directed instead to the repetition, with more elaborate apparatus, of the work of previous investigators, though it may have been perfectly well known at the outset that the results already recorded were accurate within an insignificant percentage. Of course, where doubt still exists as to the substantial accuracy of existing data, matters stand on a very different footing. An example of this has been afforded in recent years by the long prevailing uncertainty as to the specific heat of steam at constant pressure. This led, quite legitimately, to investigations in many laboratories, though in few instances have the results been such as to command the confidence of the practising engineer. In some cases the experimenter started his investigation under a total misapprehension as to the particular point in question. At the Cavendish Laboratory, for example, an elaborate research was made on this subject a few years ago, but experiments were confined to greatly superheated steam at, we believe, atmospheric pressure only. The natural result was that Regnault's value was duly confirmed. For the conditions under which these experiments were made, it had, however, never been in question. Evidence had, on the other hand, been accumulating over many years which went to show a substantial increase in this coefficient with high-pressure steam moderately superheated. The matter has now been definitely settled by the most valuable investigations completed at the Munich Polytechnic in 1905. This research, indeed, constitutes one of the few in which a really substantial contribution to the data of engineering has been made from the laboratory attached to a technical school.

It is not that our data are by any means complete, but rather—so it seems to us—that the energies of those in control are too often misdirected. Some highly valuable and interesting lines of research, no doubt, cannot be pursued, for financial reasons; but the latter did not constitute the bar which prevented these laboratories being the pioneers in the development of the notched-bar test for brittleness, which of late years has attracted so much attention among the users of special qualities of steel. Indeed, when this test first attracted attention outside of the ranks of steel makers and users, it was in some cases completely misunderstood, and in one laboratory, accordingly, the experimenter notched his bar by turning a screw thread from end to end of it, thus entirely defeating the *raison d'être* of the notch, which is to concentrate the strain on a single section of the specimen. Ferro-concrete again was developed entirely by the practician, and now that the laws governing its design are well established, we find technical colleges, instead of endeavoring to advance knowledge in some new direction, repeating experiments on this material, differing in no essential from hundreds already made, of which the results have long been public property. To call investigations of this character research is to degrade the latter term to the standard of the chemist. With the latter the word in question covers alike investigations of fundamental importance, such as those of a Kekulé or an Arrhenius, and the potterings of the dullest-witted third-year student, whose professor, in view of the fact that certain degrees are given only for original research, finds him something to do which he knows "will come out" with little difficulty.

Unfortunately, it must be confessed that chemical laboratories are not the only ones in which research work of this third-rate quality is conducted. Much of that done in mechanical and electrical laboratories is, as already stated above, of hardly greater intrinsic importance. Experiments with the oscillograph, for example, are repeated *ad nauseam*. These undoubtedly had an interest when the instrument was new, but further experiments with it in conditions not essentially different from those obtaining in half a hundred earlier observations add nothing to the general stock of knowledge, and hence, whatever their importance from the educational standpoint of the individual conducting them, should not fairly be classed as research.

Similarly, in the existing state of knowledge, little is to be gained by further experiments in the discharge of steam through nozzles. Indeed, recent works on these have added little to the pioneer investigation of Napier; and as matters stand, the discharge and velocity of flow for the forms of nozzle in common use can be computed from existing data with an accuracy sufficient for the present requirements of practice. On the other hand, the steam turbine proper undoubtedly presents an almost virgin field for pioneer research work of great importance, and here our technical schools might render service of the utmost value. Little is known, for instance, as to how the flow of steam from guide blades or nozzles is affected by the presence of a moving wheel immediately in front of them. In impulse turbines, again, information is required as to whether there actually is or is not in the clearance space an "over-pressure," to translate freely the *sur-pression* of our French friends. The law by which the efficiency varies with the relation between bucket speed and steam speed is also in need of investigation, and much interest would attach to the mapping out by experiment of the lines of flow of the fluid as it passes through the blading. A number of these points might probably be cleared up, using water as the working fluid. Indeed, for the solution of some of the problems enumerated above the use of a non-expansive fluid would possess most decided advantages; but in all cases the information which is now wanting is not to be obtained from experiments on fixed apparatus, seductive as the simplicity of the latter is. This very simplicity has, indeed, misled some experimenters into forming erroneous conclusions. Thus it has been far too readily assumed that the actual velocity of flow of an elastic fluid from a nozzle could be determined by the observed reaction, irrespective of whether the fluid was or was not fully expanded on discharge. Many of the curves published, purporting to show the relation between the drop of

pressure and the resulting velocity, have accordingly been totally misleading. If some of our numerous schools would turn their attention to the investigation of some of the points above enumerated, they would perform a distinct service to the practician, and at the same time add much to their own reputations, which will benefit little by a continuance in the humdrum field of merely confirming the results of previous workers.—Engineering.

A HOME-MADE SLIDE-WIRE ELECTRICAL BRIDGE.

BUILT AT SMALL COST.

BY HENRY C. TER MEER, E.E.

In this article a method of constructing a modified meter bridge will be described. No originality is claimed, except for the design, which was adopted in order to render the whole self-contained. The bridge is of such design that it can be constructed by any one possessing a little mechanical skill, and at a cost which should not exceed $5.

As the usual meter bridge is cumbrous, the slide-wire has been divided into four equal parts in this case. The whole is designed to fit one of the basswood boxes used for pyrographic decoration and known as "necktie boxes" (size 12¾ inches by 5¾ inches by 3½ inches high). The base on which the bridge is mounted is cut from a three-ply basswood panel. The brass bus-bars, between which the slide-wires are stretched, are made from strip brass ½ inch wide and 1/16 inch thick. Small holes are to be drilled in these pieces for the reception of the ends of the wires. Each bar is secured to the base board by two round-head screws.

A scale in four sections, each 25 centimeters long and one-half inch apart, should be carefully drawn in ink on a piece of bristol board 2½ by 10¾ inches in size. This scale is then to be pasted to the base board in the position indicated in Fig. 1. When dry the base board and the scale should be given a coat of good clear varnish. The bars are to be screwed to the base, exactly 25 centimeters apart, at the ends of the scale.

Four pieces of the No. 28 resistance wire are now carefully freed from the insulation, by unwinding it. One end of each of the wires is now fastened to the proper left-hand bar as follows: The wire is threaded through the hole, in the bar, from below, the bar screwed down so as to clamp the wire between the base and the bar, and then soldered into the hole. The wires are then fastened to the right-hand bars in a similar manner, after being drawn taut.

Four dry cells (1½ inches by 4 inches) are required; one being used to operate the buzzer. The other three are connected in series, wires being brought out from each cell and connected to the left-hand four-point switch indicated in the wiring diagram, Fig. 2. By means of this arrangement one, two, or three cells may be used in series, according to requirements. The battery circuit of the bridge proper does not include the magnet coils of the buzzer; it passes through the contact and armature to the frame as indicated. In order to deaden the sound of the buzzer as far as possible, it is wrapped up in a sheet of asbestos paper and packed into a cardboard box filled with asbestos wool. The buzzer is controlled by the central switch.

The four resistance coils (1, 10, 100, 1,000 ohms) are thrown into or out of circuit by means of the right-hand switch. These coils may be obtained from an instrument maker, wound with any degree of accuracy. It is, however, cheaper to wind them. They are to be wound, non-inductively, on wooden spools. For this purpose, measure off the wire (as per table) accurately and double it; the doubled wire is then wound onto a suitable spool, beginning at the loop. As the accuracy of the measurements depends to a very great extent on the resistances of these coils being what they are supposed to be, viz., 1, 10, 100, and 1,000 ohms, the resistances of the coils should be measured and adjusted accordingly.

1 ohm = 5 feet of No. 16 B. & S. gage "Superior" resistance wire.

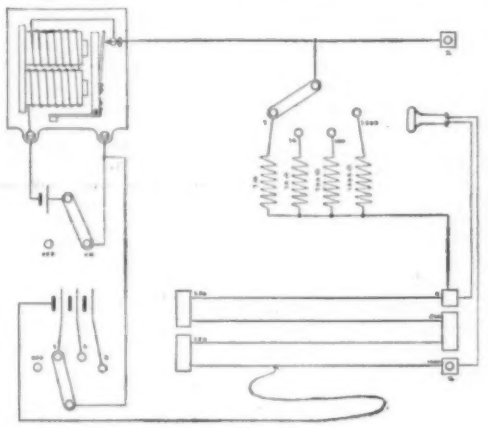
10 ohms = 50 feet of No. 16 B. & S. gage "Superior" resistance wire.

100 ohms = 30 feet 10½ inches No. 28 B. & S. gage "Superior" resistance wire.

HOME-MADE SLIDE-WIRE BRIDGE.

1,000 ohms = 308 feet 9¾ inches No. 28 B. & S. gage "Superior" resistance wire.

These lengths are calculated for "Superior" resistance wire; when other brands are used, they must be changed accordingly. After the coils have been wound, they should be saturated with melted paraffin.



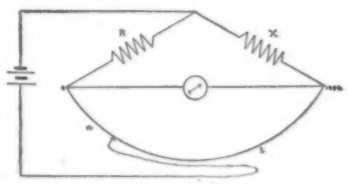


DIAGRAM OF ELECTRICAL CONNECTIONS FOR THE SLIDE-WIRE BRIDGE.

The parts of the switches are to be taken from two 4-point and one 2-point wooden-base switches, and secured to the baseboard as shown. All connections of the bridge circuits should be soldered. The wiring is to be done with heavy (about No. 10) double-covered magnet wire. The batteries, resistances, and the buzzer are packed into the box, as indicated, below the base board, and securely strapped in place. The slider is made from a stout copper wire; one end being flattened out and filed to a knife edge. It is fastened to the end of an insulating handle of the thickness of a lead pencil. The lead passes through the center of the handle. A well is provided at the left-hand upper corner for the reception of the leads and the watch-case telephone receiver. The clip holds the slider when not in use.

The accuracy of the bridge depends on the uniformity of the wire (its resistance should be as high as possible, and should at least be equal to about 10 ohms), the uniformity of the scale divisions, and the values of the resistance coils. The resistances of these coils may be equal to any desirable quantities; for simplifying the calculations, 1, 10, 100, and 1,000 ohms are chosen. The resistances of the coils should therefore approach these values as closely as possible.

In order to measure resistance with this bridge, the ends of the circuit, the resistance of which is to be determined, are connected to the binding posts x x. Next the buzzer is switched on, then one or more of the cells, depending on the resistance of the circuit to be measured. If the telephone is now held to the ear and the slider applied to the slide wire, a buzzing sound will probably be heard in the receiver. The slider is then moved along the wire until a point is found at which the sound ceases to be heard, or is faintest. The scale division at which this occurs is noted, and the resistance calculated from this value and from the value of the resistance coil used. The resistance coil should be of such value that it will bring the point at which the sound ceases to be heard as near as possible to the middle of the wire.

The resistance is calculated as follows: From Fig. 3 we have the proportion

$$a : b = R : x; \text{ or } x = \frac{bR}{a}.$$

Assume that the sound ceases when the slider is at $a = 243$ (Fig. 3), then $b = 1{,}000 - 243 = 757$. Also assume $R = 10$. Then $x = \frac{757 \times 10}{243} = 31.1 +$ ohms.

BILL OF MATERIALS.

1 basswood box 12¾ in. by 5¾ in. by 3½ in. (necktie box)	$0.50
1 three-ply basswood panel 10 in. by 14 in.	.25
1 double pole watch case telephone receiver, 75 ohms	.65
1 receiver cord	.16
1 yard single conductor flexible cord (silk)	.10
2 binding posts (English pattern)	.20
2 four-point wooden base switches	.26
1 two-point wooden base switch	.10
4 dry cells (1½ by 4 in.)	.64
1 buzzer	.18
1 brass strip ½ in. by 1/16 in. by 6 in.	.20
60 feet No. 16 B. & S. gage single silk-covered (approx. ½ lb.) "Superior" resistance wire	.95
350 feet No. 28 B. & S. gage single silk-covered (approx. 1/6 lb.) "Superior" resistance wire	.50
Total	$4.79

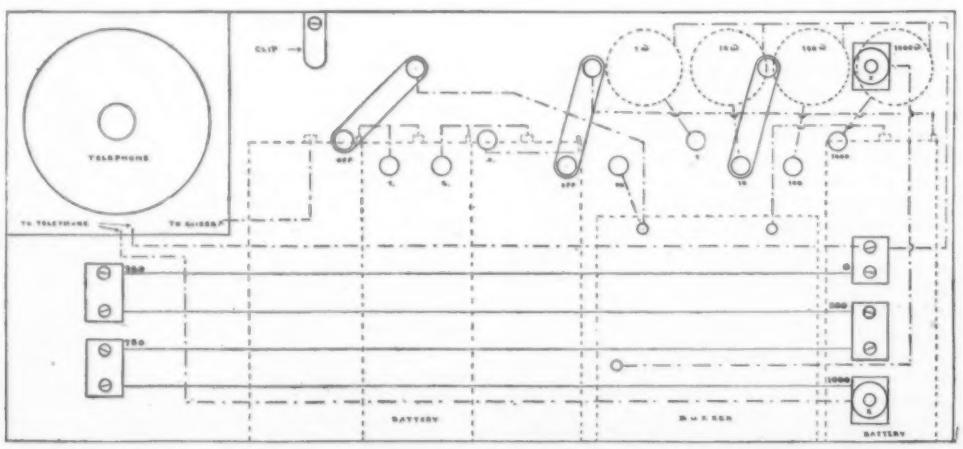


DIAGRAM OF ELECTRICAL CONNECTIONS FOR THE SLIDE-WIRE BRIDGE.

In connection with the increase of the height of the Assouan dam, it has been found that the alteration necessary to the sluices will for the most part be very slight in character, notwithstanding the fact that the level of the water impounded is to be raised by 23 feet. In the case of the lock gates, however, two new ones 72 feet deep will be required, while the locks themselves will have to undergo some rearrangement. A fifth lock is to be constructed north of the existing four, the walls of which will have to be strengthened. One of the most interesting details of the undertaking will be the removal of the present gates in each case by about 525 feet, so as to fit them into the recesses formerly occupied by the smaller gates. Considering that the two largest gates, measuring 70 feet high by 34 feet wide and weighing nearly 100 tons, will have to be turned round to travel, and lowered about 16 feet, the operation will necessarily require considerable care.

THE DEVELOPMENT OF ARMORED WAR VESSELS.—VIII.

ARMOR PLATING IN THE UNITED STATES.

BY J. H. MORRISON.

Continued from Supplement No. 1658, page 239.

THE first ironclad frigates built in Europe having ram bows were the "Magenta" and "Solferino" for the French navy, and launched late in 1862. The "Hercules" and the "Bellerophon" for the British navy were commenced a little later.

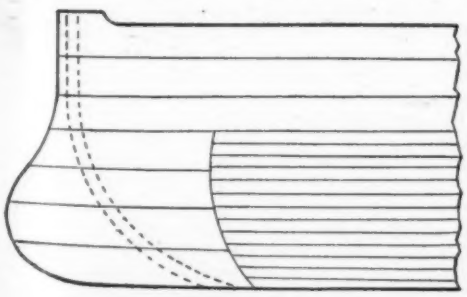
It was but about six months later after the "Manassas" ramming engagement, when the ever-memorable contest of the "Merrimac" in sinking the "Cumberland" in the James River, or Hampton Roads, on March 8, 1862, took place; and as this Confederate ironclad war vessel was more of a type to show the merit of a ram in an engagement than was the "Manassas," it intensified the interest of the naval powers in that fixture to a war vessel. The naval powers of Europe were much surprised at this unexpected revolution in naval warfare, and as one British authority said at the time: "For the first time, the newest applications of science have been in a fight between foes of equal courage. Who would have thought it possible, that after England and France had theorized so long on iron-plated and iron-prowed vessels, that the first real trial should have been made by the inhabitants of the peaceful New World, met in unnatural strife?" The ram, or iron prow, was now a factor to be taken into consideration in the designing of the ironclad war vessels, and it was most generally adopted in a few years, with the exception of our "Monitor" type of vessels. What gave this instrument further recognition was the occasion of the loss of the Italian ironclad "Re di Italia," on July 20, 1866, off the island of Lissa, Austria, by being rammed by the Austrian armored vessel "Ferdinand Maximilian" during an engagement of the Italian with the Austrian fleet. These vessels were about the same dimensions of hull. The Austrian vessel had a short, snub-nosed ram that was driven into the vitals of the Italian vessel, at the lower edge of the armor, or below, that caused her to sink in a few minutes. This was the first engagement where fleets of armored vessels, heavily armed, had been opposed to one another, and where the ram had been successfully used. This settled the question of the value of the ram on large sea-going war vessels.

There was a naval engagement during our civil war between the hostile fleets on the Mississippi River that had much influence at that early day to confirm the good opinion held by some experts for the ram or prow. That was the fight before Memphis, Tenn., on June 6, 1862, between the gunboats under Flag Officer C. H. Davis and the ram fleet under Col. Charles Ellet, Jr., of the War Department, against the Confederate river defense fleet composed of eight armed rams. These vessels could more properly be styled *steam battering rams*, for they had no iron prow or ram.

The Union ram fleet was composed of nine Ohio River steamboats, four sidewheel and five sternwheel, the former being the larger and more powerful of the fleet. They were:

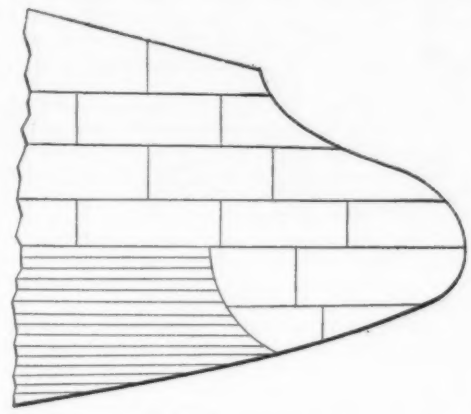
	Built.	Hull.	Boilers.	Engines.
				in. ft.
"Lancaster 3".....	1855	176 × 29.5 × 5 3	3	2 of 20 × 6
"Switzerland".....	1854	178 × 36.8 × 8.0	4	2 of 24 × 8
"Queen of the West"	1854	176 × 33.0 × 7.5	5	2 of 22 × 8
"Monarch".....	1855	178 × 32.0 × 7.5	4	2 of 22 × 8

The sternwheel boats were the "Lioness," "Samson," "Mingo," "T. D. Horner," and "Dick Fulton." The sidewheel boats were fitted out at Cincinnati, Ohio,



"ROANOKE."

and the sternwheel boats at Pittsburg, Pa. The alterations made originally in the vessels, to adapt them for the special service of ramming, is thus related to the writer by one who was interested in such matters at the time. The alterations mainly consisted "in the deck guards being sawed off close to the hull, from the stem to stern, and near the outer edge of the main deck there was built up, all around the vessel, to the under side of the deck above, and covering the water wheels in the sidewheel boats, a timber bulwark, in some of the vessels in one course of about 12 inches, and in others of two courses. The hold of the vessel for 15 or 20 feet from the



"DUNDERBERG."

stem was filled in solid to the under side of the deck with timber. Hog chains were fastened to the ends of the boilers on the vessel and running from the tops of the boilers were fastened to the deck, to keep the boilers in place during the shock of ramming. The pilot houses were covered with oak plank to protect the pilots, and on a few of the rams were covered with plate iron." A naval officer that was in command of one of the western river ironclads at this time informs the writer: "My recollection of the Ellet rams is that they were filled in at the bow with timber and made practically solid for several feet back, and also strengthened by iron straps around the stem extending aft several feet on either side, and bolted through and through. They did not have the iron ram bow."

The Confederate ram fleet was originally composed of fourteen vessels, several large and powerful towboats that had been in service towing vessels to and from the passes of the Mississippi River to New Orleans, and two of the vessels had been on Morgan's line from New Orleans to Galveston, Tex. Many of the officers and crews on these vessels had been in the employ of the Morgan line prior to the civil war. In January, 1862, three months after the "Manassas" had attacked the Union fleet at the passes of the Mississippi River, and less than two months before the "Merrimac" or "Virginia" was completed, these vessels of the Mississippi River ram fleet were purchased, and operations commenced toward fitting them out for the special duty of steam battering rams. The alterations made in the vessels were stated by the commodore of the fleet: "Their machinery was protected by an inner bulkhead of 12 inches square timber, bolted together every 18 inches; an outer bulkhead of 6 inches by 12 inches timber, bolted as above; space between bulkheads, 22 inches. This space was filled with ordinary-sized cotton bales, compressed so as to fit between the bulkheads. The bales were forced together by jack screws, and the bulkheads united by two iron bolts over the top of each bale. The outer bulkheads were plated with railroad iron one inch thick by two and one-half inches wide. This offered a perfect resistance to the enemy's heaviest guns as tested at Fort Pillow. The bows were made solid inside with 12 inches square timber, bolted together, and sheathed outside with 4 inches oak plank for 20 feet on each side. Iron of one inch by two and a half inches was bent around the stem, and extended back to the end of the sheathing." It will be noted how much better protected from hostile shell and shot these Confederate rams were fitted than were the rams of Col. Ellet's fleet. The former were armed with a total of about twenty guns of 24 and 32 pounders, while the Union fleet had no guns whatever on board, having about fifteen sharpshooters on each vessel to pick off the officers and "men behind the guns" of the enemy's fleet. There were engaged in this battle before Memphis but two of the rams of Col. Ellet's fleet, the "Queen of the West" and the "Monarch," both sidewheelers. It was only the bold and daring manner in which these two light-built vessels dashed ahead of the slow and unwieldy gunboats, and attacked the Confederate fleet of rams on their own ground, that in a few minutes threw the latter in confusion, but did not prevent them from inflicting serious injury upon the "Queen of the West." The result of this engagement, as far as can be made from the more than usual disagreeing official reports, would appear to be that three of the Confederate vessels were rammed and sunk, four disabled from effect of shells, and run ashore, and one escaped at the time. The armored gunboats of the Union fleet, as soon as they could get into position for attack on the Confederate vessels, made terrible havoc on the vessels by the unerring aim of the gunners and the use of the explosive shells. It was the first battle that had ever been fought where there were a fleet of rams engaged on both sides. It was a most desperate fight while it lasted; and in little over one hour's time had wiped out the Confederate Mississippi River defense fleet. Flag Officer Davis in his official report of the engagement makes reference to the service of the rams in these words: "The attack made by the two rams under Col. Ellet, which took place before the flotilla closed in with the enemy, was bold and successful."

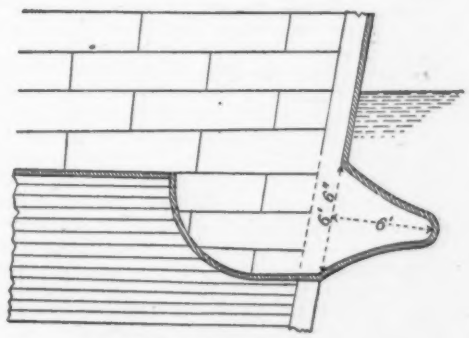
It appears at this late day that it was an error of judgment on the part of the Union Navy Department not to have adopted the use of the beak or ram bow on some large reconstructed ironclad vessels during the first stage of the rebellion. It was suggested to the department by one of our prominent shipbuilders to cut down some of the wooden steam vessels of the navy, cover them with iron armor and fit them with a ram, as was done later with the steam frigate "Roanoke." There is no doubt they had their hands full fitting out the several blockading fleets at the time.

Charles Ellet, who laid his views of the worth of steam battering rams before the Navy Department some years before the civil war, as mentioned in a previous chapter, again brought the subject to their notice, and on May 29 and June 21, 1861, advised the Navy Department at Washington of his views on the subject, considering the military situation of that period. He wrote President Lincoln on September 14 following, and his opinion is given in part in the following letter:

"I have endeavored for more than six years to induce the Navy Department to take up and investigate the proposition to introduce the steam battering ram in naval warfare. But I have not been able to attract the serious attention of the department, though I have pressed the subject upon three successive administrations. . . . The rebels at New Orleans and Mobile are also at work, as I informed the Secretary of the Navy some four months ago, building rams to run down our blockading vessels; and since we have nothing to oppose to them, as we ought to have, I greatly fear that we shall soon receive accounts of some serious disaster in that quarter.

"My principal object in calling your personal attention to this subject now, however, is to recommend the steam battering ram as the only effectual means of defending our rivers and harbors against the modern iron-plated and shot-proof vessels which England and France are introducing in their navies.

"CHARLES ELLET, JR., Civil Engineer."



"RE DI ITALIA."

It is seen by comparing the dates, that this advice was given to the President a month prior to the attack made by the "Manassas" on the blockading fleet at the passes of the Mississippi River. The depart-

ment had been previously advised of the building of the southern rams, as found in the records of the Union and Confederate navies. The contracts for the Confederate ironclad rams on the Mississippi River had been made many weeks before, and the "Virginia" had been rebuilding at Norfolk, Va., for a few months; and yet nothing done by the Union Navy Department to meet the emergency of the time with a rebuilt armored vessel having a ram bow. This month it is known the steam frigate "New Ironsides" was placed under contract, but it took nearly a year to complete the vessel for actual service. It was not until after the "Virginia" rammed the "Cumberland" that any emergency measures were taken to adopt the ram. The steam frigate "Roanoke," that was a sister ship of the "Merrimac" or "Virginia," and in Hampton Roads at the time of the "Merrimac"-"Monitor" engagement, was taken about two months later to the Brooklyn navy yard and there razeed and clad with iron armor, and a ram of iron similar in form to that built in naval vessels of a later day was added to the vessel. To form this ram for the vessel the forward armor plates were projected some feet beyond the stem of the vessel, and farthest at the waterline. At the extremity a solid piece of iron having a curved front was inserted and firmly secured between the plates projecting from the two sides of the stem; and the angular space between this front plate and the bow proper was filled in solid with timber, and fastened in place with bolts.

The last vessel that was built for the United States navy during the rebellion, having a ram bow, was the steam frigate "Dunderberg." She had the most formidable shaped ram of any vessel of that period, and for several years after; it was certainly a business-like tool of war. This ram was an extension of the bow of the vessel proper. To form this ram the bow of the vessel was built solid for thirty feet, and for fourteen feet from the forward end of this filling the solid mass of timber was shaped to form the ram proper. The width of the ram 8 feet from the forward end was composed of 18 inches of timber and 9 inches of iron armor, 4½ inches on either side, making 27 inches in extreme breadth at that point. The iron tip of the ram was 9 inches wide by 21 inches long. The surface of the ram was covered with iron armor, same as the hull of the vessel, to make it more solid and prevent it being injured in case of ramming a vessel. The "Kalamazoo" or "Colossus," that was commenced in 1864 at the Brooklyn navy yard, was so designed as to have a ram very similar to that built in the "Dunderberg."

This completed the ram-fitted vessels and the steam battering rams of the Union Navy Department during the civil war. They were few in number, from the cause that the "Monitor" type of naval vessel, that were neither originally designed nor fitted as rams, were more popular for the Union cause during the rebellion than any other type of ironclad vessel. The original "Monitor" had shown itself under skillful handling to be capable of receiving without many injurious effects some hard punishment in a naval engagement and it was considered best "not to change horses in crossing a stream."

There were two iron-hull torpedo rams built, the "Alarm" at the Brooklyn navy yard in 1873, and the "Intrepid" at the Boston navy yard in 1874. In 1893 there was constructed at Bath, Me., the harbor defense ram "Katahdin."

The ram will soon be a weapon of war of the past. There has not been a naval engagement since the battle at Lissa in 1866 where any use has been made of the ram. This has been due in a great measure to the gradual increase of the power of the naval gun, that has compelled the naval battles of the last decade to be fought at long ranges. In the Russia-Japan war the main naval engagements were fought at distances of from two and one-half to four miles. Improvements in torpedoes, the development of the submarine vessel for naval purposes, and smokeless powder have had a marked influence of late years toward the laying aside of the ram. Much has been learned through the accidental ramming between foreign war vessels during practice maneuvers, and during a fog, with fatal results. That of the "Iron Duke" and the "Vanguard" in 1875, and the "Victoria" and "Camperdown" in 1893, all of the British navy, were the most striking examples; and from the latter date may be taken the time when the ram began to lose its hold as a war weapon with naval officers as being an instrument as likely to prove destructive to friend as to foe. It was at this time a most valuable paper was written by Admiral W. Laird Clowes, an English naval officer, on "The Ram in Action and in Accident," in which he drew the following conclusions from seventy-four attempts at ramming: "The obvious conclusions are somewhat remarkable. One is that if two ships have sea room, and be fully under control, it is actually more dangerous to try to employ than to try to escape the ram; and that under these conditions it is practically hopeless to dream of ramming effectively, since there is no recorded case of the operation having been performed, although it has been attempted at least thirty-two times. Another is that in such circumstances the rammer stands about the same chance as the rammed does of sustaining non-fatal injuries. Another is that the risks attendant upon ramming are the same, whether the attempt be made at sea or in narrow waters. The exact similarity of A(2) and B(2) (the effect on the attacker, where both ships had sea room, and where both ships were in narrow waters) is indeed extraordinary."

(To be continued.)

THE MANUFACTURE OF SLACK BARRELS.

AN INDUSTRY DEPENDENT ON OUR TIMBER SUPPLY.

ONE of the most common articles in every-day use is the barrel. To the average man a barrel is simply a barrel, and he never stops to think how seriously trade would be handicapped if the barrel supply were suddenly to give out or if some individual or corporation succeeded in cornering the barrel market. Neither of these things is likely, but a moment's thought on either will serve to convince one that the homely barrel is a more important factor in industry than it is thought to be. This is particularly true of the "slack" barrel. In the cooperage trade barrels are commonly classified as "tight" and "slack." The slack barrel is used to hold commodities which are not liquid, such as lime, salt, cement, flour, sugar, vegetables, and a great many other articles. In many respects the slack barrel is an ideal container for such material. It is strong, durable, and easily handled. The articles which it contains are thoroughly protected, and after being once used, the barrel may be again used and reused for many different purposes, and after having served its time as container it has a final use as firewood.

Some of the commodities which were once almost entirely packed and shipped in barrels are now being handled in sacks, but the users of the barrel insist, with much reason, that the barrel has no superior. It is the strongest package on the market, is sanitary, and is easy to handle. A sack, on the other hand, is often damaged in transit, and when it contains food stuffs, the material is likely to be contaminated. This contamination arises not only from unclean cars, but also from the products coming in contact with other articles which seriously affect them. Protection against damage by moisture is often especially important. There is a lively contest between the makers of barrels and the makers of sacks, to secure the trade of sugar, flour, and cement manufacturers whose products were once chiefly put up in barrels and which are now extensively put on the market in sacks. The sack, of course, is a cheaper package, and the increasing scarcity of timber and the rise in price makes the situation doubly difficult for the manufacturer of slack cooperage stock.

The ordinary slack barrel consists of some sixteen or seventeen staves, two heads of three pieces each, and half a dozen hoops. No complete statistics are available upon the amount of timber annually used in the manufacture of slack cooperage, but reports indicate that last year there were produced over a billion staves, over 200,000,000 sets of heading, and more than 300,000,000 hoops. Many wire hoops are also used. It is probably safe to say that altogether more than 800,000,000 board feet of timber are used annually in the manufacture of slack barrels in the United States, and that if the barrels which are made in a single year were stood on end side by side, they would cover an area of over 80,000 acres.

Because of its great strength and toughness, elm has long been the principal wood used for staves for high-class barrels and hoops, and it will be the favorite until the supply is exhausted. There has been a very great increase in the use of gum for staves within the last few years. Basswood has always been the preferred wood for heading because of its soft, even grain, but it, too, is being gradually replaced by gum.

The production of elm lumber in the United States has decreased over 50 per cent in the last seven years. Elm is cut most largely in the Northern States, and particularly in Wisconsin, Indiana, and Michigan, and the exhaustion of the supply in those States has had a most serious effect upon the slack cooperage industry. One of the prominent manufacturers estimates that there are not half the staves made in Michigan now that there were ten years ago. Saginaw, which used to be the principal home of the industry, is now producing stock only in a small way, and as a matter of fact, most of the cooperage stock made in Michigan now comes from the Northern Peninsula instead of from the Southern Peninsula, as was formerly the case. It is the opinion of one of the best-informed and most prominent manufacturers in Ohio that to-day there are not 1,000 staves produced in that State where there were 10,000 staves made ten years ago.

Red gum grows most abundantly in Arkansas, Missouri, Mississippi, and Tennessee, and with the increased use of this and other Southern woods in the manufacture of slack cooperage, we find that the industry is shifting southward at a rapid rate. It is said that there are now a score of first-class plants making staves and heading in Louisiana, where there was only one of any large capacity ten years ago. It will be only a few years, however, until the maximum output of these States is reached, and there, too, the manufacturers will be compelled by the scarcity of material to hunt vigorously for a supply of timber.

So far, forest utilization in the United States has been of the most wasteful kind, and only a relatively small percentage of the actual wood content of our trees has finally reached the consumer in the form of some useful article, whether that be board or stave or shingle. Studies made by the Forest Service of the Department of Agriculture indicate that in the manufacture of staves and hoops, only 50 to 60 per cent of the contents of the log which goes to the mill finally emerges in the manufactured form, and that, with heading, perhaps no more than 25 per cent of the actual volume of the log finally goes into barrel heads.

Much of this lack of utilization cannot be prevented, yet there are possibilities of greater economy than is commonly practised. For instance, upon careless inspection, logs are often assumed to be suitable for stave bolts and are cut into lengths which are multiples of 32 inches, and are subsequently found to be fit only for heading, which requires 21-inch lengths. This causes much waste which could have been prevented by a more careful determination at first of the purpose which the log was best fitted to serve. It is interesting to note that at an immense sawmill now being erected in Louisiana, logs the full length of the tree will be brought in from the woods and cut into suitable lengths at the mill. This is a commendable innovation in sawmill practice.

Waste also occurs sometimes because logs lie in the woods or on the yard until they are too checked to use. Waste is increased, too, if the bolts are split instead of sawed, since in this case the first and last staves cut from each bolt must be discarded because the sides are uneven. Hence, a given volume of timber will produce more staves if the bolts are sawed than if they are split.

It is equally important to utilize the waste which unavoidably occurs. Every part of a tree may serve some useful purpose, and officers of the Forest Service say that the time when it will do so is rapidly approaching. Manufacturers of slack cooperage stock are confronted by the same problems which are now meeting almost every user of wood in the United States, an increasing scarcity and a correspondingly higher price. The farm wood lot has frequently furnished timber for the maker of hoops and staves and heading, and it is the opinion of some who are best informed upon conditions in the slack cooperage industry, that if properly managed, these wood lots could be made the source of supply for a large proportion of the timber required for barrels.

RECOVERY OF COPPER FROM SCRAP.

A COMPARATIVELY new industry has sprung up in the refining of non-ferrous scrap metal, and the present high prices asked for all metals of this class have led to unusual activity in the scrap market. Scrap producers are anxious to realize on their waste metal and competition is keen for the purchase of raw material by the refiners. Copper is getting its due share of attention, and some care is necessary now in handling the ever-increasing traffic in copper and brass scrap.

Brass and other alloy scrap is recovered by remelting in crucibles with new metal. Fine particles of brass, such as occur in ashes, skimmings, and sweepings, are recovered by a system of washing and jigging. Concentrates obtained from jigging processes are smelted in a reverberatory furnace, or they are melted down in crucibles, or oil-burning furnaces, and cast into ingots.

Copper scrap is treated differently, according to the character of the material. The copper may be in the

metallic state, as in trimmings from copper sheet, borings, grindings, punchings, etc., or it may exist in chemical combination with some other element. It is often received and combined in copper scale or blue vitriol.

Metallic scrap copper may be melted in reverberatory furnaces of similar design to those used in the copper mining districts. The slag skimmed off consists of impurities originally contained in the charge, and combinations of copper with oxygen and the firebrick lining of the furnace. The slag may contain from 30 to 70 per cent copper, which is recovered by smelting in a cupola or small round water-jacketed blast furnace.

Certain processes of manufacture yield some very dirty scrap mixed with grease and refuse, which appear almost worthless. If the metal is present in paying quantities, however, it can be recovered, no matter how much polluted, by a judicious system of drying, sorting, and smelting. The Allis-Chalmers Company builds a complete line of concentrating, refining, separating, and smelting machinery for use in reducing scrap, as well as for every sort of mining and reduction processes.—Mines and Minerals.

THE MINING OF MONAZITE.*

A THORIUM-YIELDING MINERAL.

BY DOUGLAS B. STERRETT.

THE demand for thorium for the manufacture of Welsbach and other forms of incandescent gas mantles has increased yearly, and until some other invention takes the place of these mantles this demand will continue. Improvements are made from time to time in the manufacture of gas mantles, and two new inventions with this object in view have been reported—one in use in Germany, the other in England. The German mantle uses a form of copper cellulose impregnated with the proper salts; the English mantle is made more durable by adding an ingredient called "laddite" to the thorium and cerium solution in which the mantle is dipped. It is said that the latter mantle has not been injured after burning 2,500 hours.

The minerals from which thorium and the other rare metals used in the manufacture of gas mantles are obtained are monazite, thorianite, and thorite. The bulk of the supply of thorium is obtained from monazite, which is essentially an anhydrous phosphate of cerium, lanthanum, and didymium, containing a small and variable percentage of thorium. Though occasionally found in crystals and masses of many pounds weight, the source of the commercial material is in the form of sand. The grains are opaque to translucent and sometimes transparent, and they vary from light yellow to reddish yellow to brownish in color. They are also sometimes slightly greenish. The freshly broken or unaltered mineral has a resinous luster. This luster is brilliant, especially on the cleavage faces. The mineral is brittle and has a hardness of 5 to 5.5. It can readily be crushed between the teeth and yields a soft grit, quite distinct from the harder minerals sometimes mistaken for it. The specific gravity varies from 4.9 to 5.3, and is mostly over 5.

At present monazite is commercially worked in the United States only in the Carolinas, where the area in which workable deposits have been found is growing yearly, especially to the southwest in South Carolina. Practically all of the rocks of the monazite region are either gneisses or schists. The most important formation includes both of these types and is called Carolina gneiss. Other rock formations are gneissoid and porphyritic granite, hornblende gneiss, and diorite, pegmatite, peridotite and allied rocks, and diabase.

The rocks of this Carolina region have undergone such extensive weathering that good outcrops are the exception, and a thick mantle of residual soil covers much of the country. The kind of rock underlying certain soils can be determined, unless decomposition has been too thorough, by studying the outcrops and the gradations from such exposures into the residual soil. Thus the nature of the soils furnishes a clew as to the probability of monazite being present in quantity in the gravel of the streams; and, conversely, the nature of the country rock that a stream drains can often be told, and the probable occurrence of monazite be conjectured by examining the débris in the gravels of the bottom lands and of the stream bed.

The Carolina gneiss, on partial disintegration and decomposition, often forms a gravelly soil with a red clayey matrix. This is especially characteristic of the graphite-cyanite type, which is abundant in parts of the region. The pebbles are composed of small fragments of the original rock, often tufts of cyanite, impregnated with hermatite or limonite, or small pieces of pure iron ore.

Nearly all of the monazite shipped from the Carolinas has been obtained from gravel deposits. These deposits lie in and along the stream and creek beds, where the monazite has collected after liberation from the decomposing gneisses and schists of the region. A part of the production for 1906, however, was obtained from a monazite-bearing gneissic rock by crushing and then separating on concentrating tables. The percentage of monazite contained in the ore treated in either type of deposit is small and probably does not often run over one per cent.

The usual method of working the gravel deposits has been washing in sluice boxes, though in 1906 concentrating tables were employed at several places. The form of table most used is the Wilfley or one of similar type. It is set up at the mine as convenient as possible to the gravel deposit to be treated, and is operated by a gasoline or kerosene motor. The gravel is dumped into a shaking hopper through which water is continually passing. The sand is washed through the hopper and passes over the table, while the oversize is shoveled out. At one mine the gravels are raised by a mechanical elevator and the oversize is removed in a revolving screen, from which the sand is passed over a table. In the better class of machines, a number-one product can be taken off in the first washing, and the middlings be passed over a second time along with new sands. In some cases, however, where only two grades are separated, concentrates and tailings, a considerable quantity of rough concentrates is first washed out and then carefully sent over the machine a second time. In this way the grade of the sand is raised, and a very clean product is obtained.

The degree of concentration it is possible to attain by wet methods depends largely upon the composition of the gravels to be treated and the care used in treating them. Where black sands, such as magnetite, ilmenite, etc., and other minerals with a high specific gravity are abundant it is difficult to bring the concentrates up to 50 per cent monazite, even with good concentrating tables, and the product from sluice boxes may run as low as 15 per cent and under. In more favorable deposits, where the percentage of black sand is not large, a concentrate running 80 or even 90 per cent can be obtained with concentrating tables, while in sluice-box washing the grade can be brought up to 70 or even 80 per cent. Where the monazite is separated from the hard rock formations the grade has been brought up to 95 per cent and over by the use of concentrating tables. Taking the monazite region as a whole, there are not many large gravel deposits which will yield concentrates of over 40 per cent monazite in sluice-box concentration, and the average yield of crude monazite would probably not be far from 30 per cent. Should the use of concentrating tables increase, the grade of the crude monazite produced will be raised correspondingly.

Formerly the deposits of monazite-bearing gravels in the bottom lands along the creeks and streams were worked without any thought of the land being left in such a condition that farming could be resumed after mining had ceased. So the soils were washed away, and the gravels were piled up in irregular heaps and ridges. In this way the best farming lands were being ruined, and those farmers who had leased their monazite deposits found themselves possessors of nearly worthless land, with only the money received on the leases. This has been remedied in many cases by more systematic working of the gravel beds. The top soil is thrown on the side of the working pit opposite to that on which the deposit lies, and the underlying gravel is washed. When the next block of gravel is opened the soil is thrown off upon the gravel already washed in the adjoining pit. By spreading the gravel out somewhat evenly and placing the soils smoothly over it nearly the whole land is kept in condition for farming after the monazite has been removed.

It has been found that, when the stream gravels are washed for monazite and then left for a few months, especially in rainy weather, another crop, so to speak, of monazite can be obtained. This results from the washing in of monazite from the surface of the surrounding fields and hills, where it has been left by the decomposition of the original rock matrix. With this end in view, the land draining into the streams should be plowed now and then, to give the surface waters a chance to wash the monazite into the stream beds. In many cases the farmers have preferred to wash the stream gravels themselves once or twice, or more times, a year. The usual cultivation of their farm land keeps a fresh supply of monazite stirred up in the fields, from which much of it is washed into the creeks.

A portion of the crude monazite is shipped to the manufacturers as it comes from the mines. The greater part, however, is cleaned by electrical machinery at local cleaning mills in the monazite region. In this way the percentage of monazite in the sand is greatly increased and the freight charges on waste products are minimized. The different types of machinery in use are (1) the Wetherill electro-magnetic machine and its modifications, (2) a machine in which the minerals are deflected by electro magnets while falling, and (3) a static machine.

Of the Wetherill machines there are two specially designed, improved types operated in different parts of the region—one in North Carolina, the other in South Carolina. In these machines there are four magnetic fields, which lift the different varieties of sand from a main conveying belt passing through them. Smaller belts, between the main belt and the magnetic pole lifting the minerals, carry the sand attracted by the different magnets out of the magnetic field and drop it into proper receptacles. In this way magnetic iron is removed by the first field; titanic iron, garnet, and other minerals of similar magnetic intensity by the second; and coarse and fine monazite by the third and fourth fields, respectively. Quartz, rutile, zircon, gold, and other highly non-magnetic minerals pass off as tailings. This type of machine readily cleans the sand to 90 per cent, and is able to raise it to 95 per cent monazite by careful handling. In another type of Wetherill machine, of which several have been used in the monazite region, there is but one magnetic field, which generally removes magnetic and titanic iron and garnet, while the monazite is left with the quartz, zircon, and other highly non-magnetic minerals. The cleaned product from this machine probably averages about 80 per cent, and does not often run over 85 per cent monazite. When the field magnets are properly constructed it is possible to pass the sand through the machine a second time under a much higher magnetic intensity, and to free the monazite of many of the other minerals left with it in the first cleaning.

In the second type of the electro-magnetic machine the sand is passed over a series of belts, and the separation is effected by the deflection in a magnetic field of the grains of mineral as they fall over the ends of the belts. The different minerals are drawn out of their ordinary course of fall by powerful magnetic fields and are carried off in different chutes. In this way a very clean separation of monazite is said to be effected.

In the electrostatic machine all the minerals but monazite and garnet are lifted from the sands. This is accomplished by a cylinder about 2 feet in diameter and 3 feet long, covered with sheets of vulcanite, slightly separated from one another, 8 by 12 inches square and three-eighths of an inch thick. The vulcanite is excited by rubbing with felt-covered cylinders revolving at a high rate of speed. The speed is regulated by cone pulleys, and is made greater when the atmosphere contains considerable moisture. The sand is heated by two gasoline lamps before exposure to the electrified cylinder. The latter is revolved slowly, and all the sand attracted to it is removed by brushes.

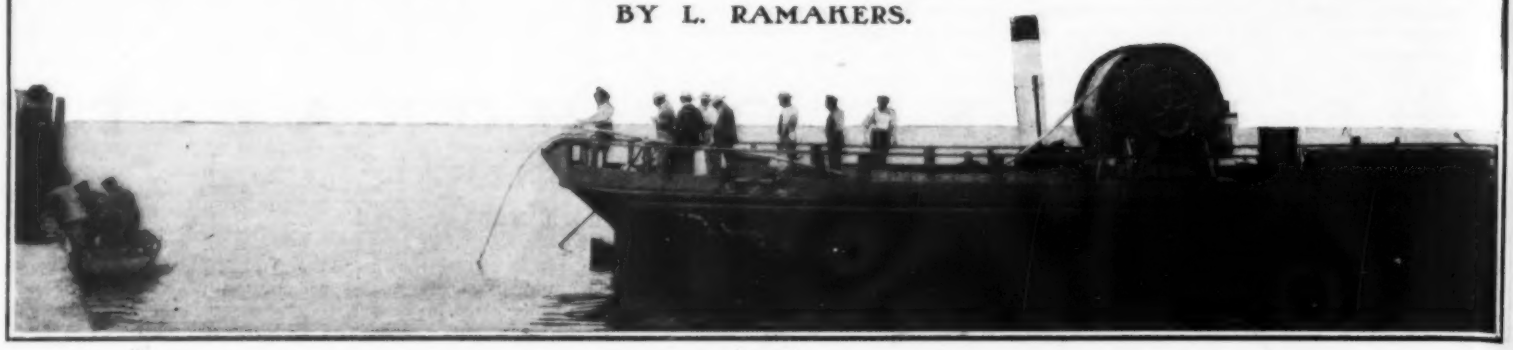
Investigations carried on by the concentrating plant of the United States Geological Survey at Portland, Ore., during 1905 and 1906 have shown the wide occurrence of monazite in the Western States. Appreciable quantities of monazite were found in samples from the gravel deposits of California, Colorado, Idaho, Indiana, Montana, Nevada, New Mexico, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. In many cases it would seem that workable deposits exist, judging from the percentage of monazite recorded in the tests. In Idaho especially there have been a number of monazite-bearing deposits. When it is remembered that many of the western deposits on which tests have been made carry gold and platinum it will be seen that they should be paying propositions if carefully handled.

* Abstracted from a Bulletin issued by the United States Department of the Interior.

As a general rule, the brush sets of a multipolar dynamo are evenly spaced around the commutator. Practical experience shows that under these conditions there are appreciable local currents circulating among brush sets of the same polarity. Such currents increase the armature losses and temperature rise, and reduce the overload capacity of the machine. Experiments which have been carried out show that by properly adjusting the position of each brush set independently of the others such local currents may be entirely eliminated.—The Engineer.

A PUPIN CABLE IN DEEP WATER.

BY L. RAMAKERS.



Considering that we have had submarine telegraph cables for half a century, the small number of submarine telephone cables may be a matter of surprise to the non-technical public. There is, however, a special difficulty as to the submarine telephone cable. Owing to its construction, the telephone cable has greater capacity and smaller inductance than a land line of corresponding resistance and length. But we know, from the researches of Oliver Heaviside, that in order to obtain clear speech, we should have small capacity and high self-induction. Where we are not confronted with insulation troubles, the two conditions may easily be combined. For submarine cables gutta-percha has generally been considered the best insulating material, in spite of its high price and its high inductive capacity. Vulcanized rubber may be used, and has indeed answered in a few of the submarine cables of the early days. But rubber is not generally trusted; and air space and paper insulation, so useful and convenient in many instances, and of small inductive capacity, are difficult of application in submarine cables, because we have to provide a suitable impervious sheath which will also bear a great water pressure.

If it were not for these mechanical difficulties, the experimental verification by Pupin of Heaviside's deductions should long ago have helped us to long-distance submarine telephone cables. Pupin showed that by adding self-inductance to the line at intervals, we can greatly increase the range of clear speech. Long lines of high or of moderate capacity exert a damping influence upon the high-frequency alternating-current waves passing through a telephone line. The damping depends upon the capacity, inductance, resistance, length, and leakage of the line—a certain leakage does not do any harm—and the frequency of the currents, and that term of the function which is more particularly known as the Pupin constant β, represents a numerical factor which teaches us over what length of line speech may be possible, or what values must be given to the chief factors—resistance, capacity, and inductance—in order to render speech feasible. When the inductance is very high, waves of all periods will practically be damped to the same amount, and the sounds will be reproduced, weakened but with their natural tones. When the inductance is very small, on the other hand, the overtones and the hissing sounds will be damped, and we obtain loud but indistinct sounds. The inductance can be increased by enlarging the copper core, when the capacity will likewise rise, however. This arrangement was tried on the English-Belgian cable, laid before these problems were clearly understood. The core was made thick to decrease the ohmic resistance, and the capacity was decreased by increasing the thickness of the gutta-percha. In the English-French cable the capacity was reduced by providing the four cores with a common gutta-percha sheath. All these early cables contain four symmetrically grouped cores, to prevent mutual interference between the two pairs.

When in 1902 an improved telephone service was wanted between North Germany and Denmark, and also between Cuxhaven and Heligoland, telephone-cable manufacturers were not prepared to supply submarine Pupin cables, with self-inductance inserted at intervals, although land cables of this type had been laid. In 1899 Breisig, of Berlin, showed that the inductance of a cable could be increased by coiling iron tape in a spiral round the core, over its full length; and later on the Danish engineer Krarup proved that fine iron wire wound directly on the copper core would serve the same purpose. The iron wire need not be insulated from the copper, which may be varnished. Krarup's suggestion was adopted by Messrs. Felten and Guilleaume in the cables of 1903, which were laid in depths of about 20 meters.

In the four-core Fehmarn-Laalland cable, each of the seven copper strands, of 1.35 millimeters, is coiled with bare iron wire of 0.3 millimeter; over this are placed the impregnated paper insulation, jute, two lead sheaths, compound, and an iron wire armoring. The Cuxhaven-Heligoland cable, 75 kilometers (47 miles) in length, is similarly constructed; the Refsneas-Soelvig cable, laid about the same time, is a gutta-percha cable.

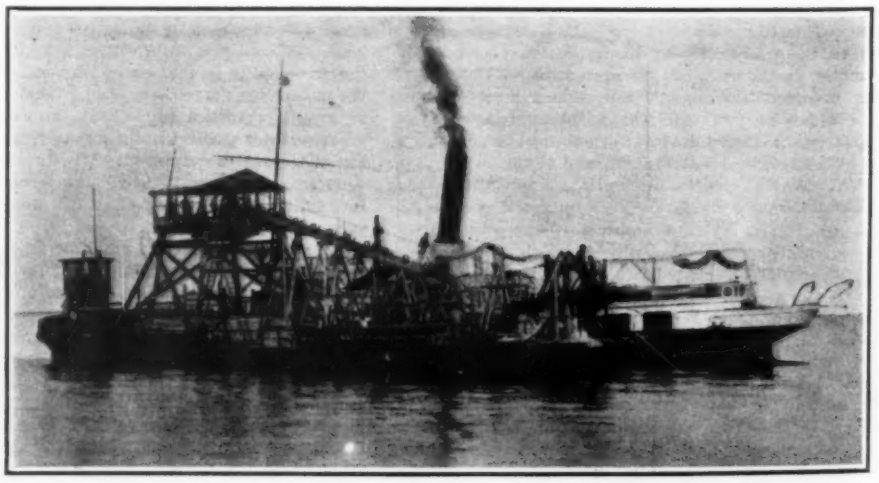
The comparative weights in pounds per yard and total costs per yard of some of these cables have been estimated by Breisig as follows: English-Belgian cable, 14½ pounds, cost $1.50; Greetsiel-Borkum cable, 13½ pounds, cost $1.05; Heligoland cable, 17 pounds, cost $1.40.

The Greetsiel-Borkum cable (30 kilometers, or nearly 20 miles in length) which is also one of the Felten and Guilleaume cables of 1903, has only half the damping constant of the English-Belgian cable—an important point for cables joined to long land lines—and was considerably cheaper.

In none of the cases so far mentioned, however, did the depth of the water exceed 40 meters. The case of the Bodensee or Lake Constance cable laid by Messrs. Siemens & Halske was different. The depth of the open lake portion between Friedrichshafen (in Würtemberg) and Romanshorn (in Switzerland) is 250 meters (820 feet), and considerable difficulties have been encountered, although the length of the cable is only 12 kilometers (7.5 miles). Dr. Ebeling's explanation of the difficulties and temporary failures, which he gave in his account of the manufacture and laying of this cable delivered before a recent meeting of the Elektrotechnische Verein, was particularly interesting. It is the first submarine telephone cable on the Pupin system, the self-inductance of coiled iron wire being inserted at intervals of one kilometer. Calculations as to the number and distribution of the induction coils required for particular purposes were given by Breisig in 1904. The cable comprises seven complete circuits.

As the water pressure is 25 atmospheres at a depth of 250 meters, experiments were made as to the strength of the cables, and the pressure was in these experiments raised to 150 atmospheres, in order to make sure that an apparently harmless pressure might not prove injurious in the course of time. The cables, provided with a double lead sheath of 5 millimeters (0.2 inch) thickness, were all crushed; a pressure of 50 atmospheres would, for instance, flatten out in two hours cables which had borne that pressure quite well for half an hour. The ordinary armoring could not prevent the crushing; but a remedy was found by coiling a steel wire of 2 millimeters thickness in a spiral round the paper insulation, the spirals being 5 millimeters or more apart. It was desired to divide the insulation into water-tight sections by inserting impervious portions in the middle, between the inductance coils. Originally the cable was made as lead cable in lengths of 500 meters, and either an inductance coil or a section insulator was alternately interposed between the different lengths. These parts were thicker than the cable itself. The iron-wire coil was common to the seven circuits, and formed a cylindrical portion of larger diameter; a section insulator formed a doubly conical piece. The armoring was continuous all over the cable, and over those thicker portions. When the laying of the cable was commenced in the autumn of 1905, however, one of the splices failed almost at the beginning; and as the season was advanced, the laying was put off till the following summer, and certain alterations were made in the cable. The alteration concerned the coils and section insulators, which are now combined. The inductance now consists, as before, and as in the cables we have mentioned, of iron wire; but the wire is coiled in alternating sections round three or four of the seven pairs of lines. The coil itself is cylindrical; the larger diameter of this cylinder is then brought down to the smaller diameter of the cores by two conical portions; and these conical portions are the waterproof seals between different cable sections. The lead sheath is, in the conical portion, supported by a conical wire spiral, and the paper insulation is replaced by gutta-percha. These repairs had to be executed on the lake shore, and the cable armoring was applied by hand

COILING THE CABLE SMOOTHLY ON THE DECK OF THE SHIP.

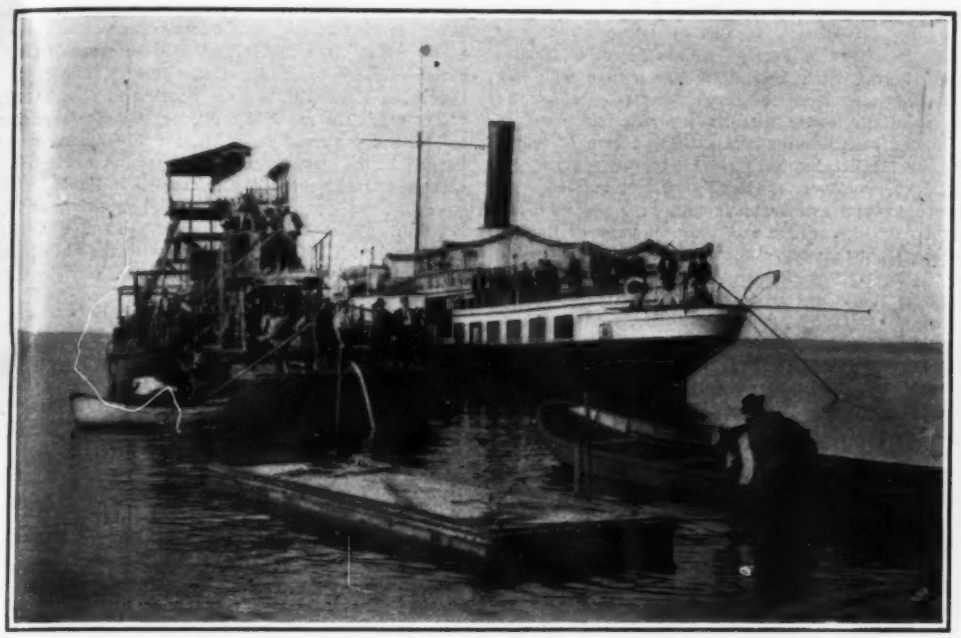


PAYING OUT THE CABLE HALF-WAY ACROSS THE LAKE.

THE PUPIN TELEPHONE CABLE UNDER LAKE CONSTANCE.

while the cable was kept under a tension of two tons. During these repairs the method of splicing was also perfected; in the case just referred to, the lead sheathing had burst over a splice.

The cable-laying machine was the machine of the well-known cable ship "Faraday," of Messrs. Siemens



THE COMMENCEMENT OF THE UNDERWATER SECTION OF THE CABLE; ENTERING THE LAKE NEAR FRIEDRICHSHAFEN.

Brothers, which was mounted, together with a raised wooden cable conduit, on a boat which was fastened alongside the saloon steamer "König Karl." The drum of the "Faraday" machine, which had a diameter of 1.7 meters (67 inches), proved too small for the thick portion of the cable, and was replaced by a new drum of 2.4 meters (95 inches). It was owing to the strain put on the cable by the repeated bending and unbending during the first laying, in 1905, that the changes already spoken of as to the induction coils and section insulators were adopted, lest weak spots should develop. As the combined width of the steamer and boat made the craft somewhat difficult to maneuver, two buoys were laid when everything was ready, and the length of 12 kilometers was thus divided into three reaches, each of 4 kilometers. The precaution proved unnecessary, and the cable was successfully laid in two hours on August 9, 1906. On the day previous a fault, traced to a defect in the lead sheathing, had interrupted the operations when 2 kilometers had been laid. After the cable was landed, tests were continued for twenty-four hours before the splice between the shore end and the land cable was effected at Romanshorn. Everything worked well. Yet a month later an earth developed in one of the seven lines in the deepest part of the lake; the other lines have remained intact.

As regards the cable, the size of a copper strand corresponds to a diameter of 1.5 millimeter. The resistance of one kilometer of double line was limited by contract to 20 ohms, the total resistance to 40 ohms, and the actual resistance is 33.5 ohms. The capacity is 0.039 microfarad per kilometer, against 0.05 of the contract; the inductance, 0.21 henry, against 0.20; and the Pupin damping constant, 0.0072, against 0.01. The Pupin constant is almost as small as in the case of the Heligoland cable, where it is 0.0065; but the copper diameter of this latter cable is 4 millimeters, and its resistance 3.8 ohms, so that almost as good a damping has been attained in the Pupin cable with only one-seventh of the cross section of copper. This is a very important gain. No doubt the telephone cable lying in the Lake of Constance has been costly, but we know now that submarine Pupin cables can be made, and how they are to be made, and the ordinary scale of expenditure must not be applied to pioneer work.

ALUMINIUM COILS.*

By FELIX SINGER.

AN electrical invention recently patented may, owing to its technical and material advantages, become of considerable importance. The well-known property of aluminium to become covered with a layer of oxide, even at ordinary temperatures, which, although hardly noticeable, offers such a resistance to the electric current that a potential difference of about 0.5 volt is required in order to break it down, is being utilized (in accordance with the above-mentioned patent of a German electrician, Mr. Robert Hopfelt) for winding magnet coils, solenoids, etc., with bare aluminium wire, the turns of which touch each other in the same manner as if the wire were specially insulated. It is clear that only the single layers of such a coil need to be insulated from each other by intermediate layers, as the potential difference between the same is greater than that between adjacent turns.

Theoretical and practical tests, made by prominent authorities, have fully proved, among other things, the advantages claimed for this invention: 1. An economy in cost of 40 to 50 per cent, as compared with insulated copper wires hitherto used. 2. An economy of about 55 per cent in weight. 3. A far greater safety in operation for many purposes; for instance, in damp places or places filled with gas, for electric railways, crane motors, etc.

As aluminium oxide does not possess the property of coming off in thin layers, like the oxides of all other metals used for electric lines, it is claimed that this natural insulation is superior to all other insulations, such as India rubber, silk, cotton, etc., also in regard to its durability and constancy at a high temperature. Aluminium coils will practically stand a temperature of more than 100 deg. C. (212 deg. F.), provided the body of the coil and the intermediate layers be made of incombustible material.

nium wires was greater than that of one of copper wires.

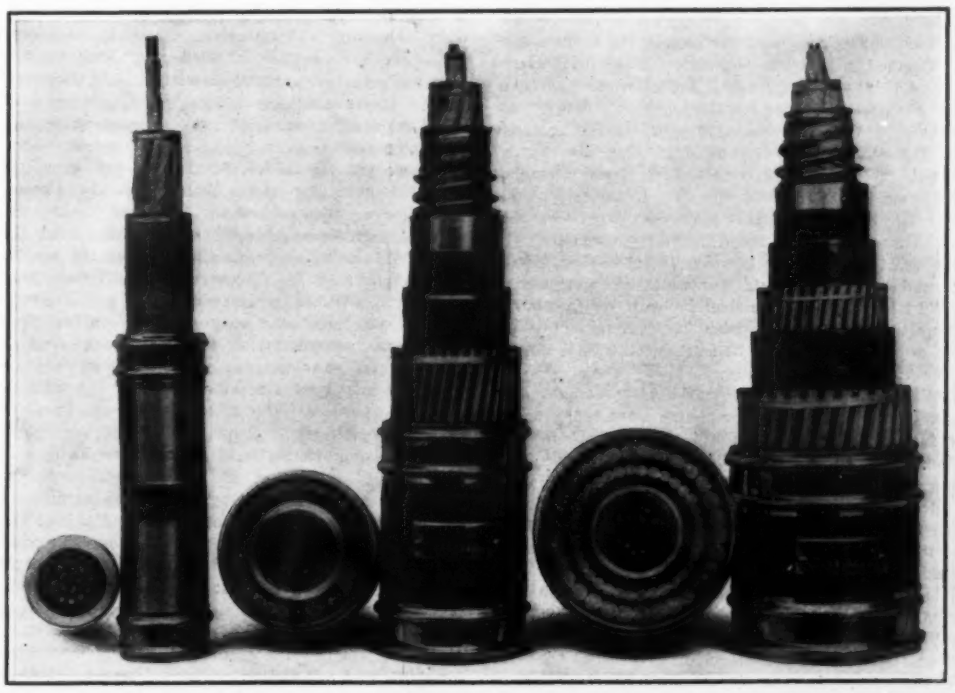
Owing to the low conductivity of aluminium (which bears a ratio to that of copper wire of 1:1.7), the question as to the space required in using aluminium wire is of the greatest importance, especially for the construction of electrical machines. Calculations made in this direction have shown that aluminium wire up to a diameter of 1.3 to 1.5 millimeters does not require a greater space than round copper wire covered with a double layer of silk or cotton, in spite of its greater volume.

When calculating aluminium coils, it is also to be noted that the temperature coefficient of resistance of aluminium is about 10 per cent less than that of copper wire. Besides, aluminium coils will cool down better than coils of insulated copper wire. Many tests have shown that, in order to attain the same temperature, an aluminium coil can stand an overload of about 20 per cent more than a copper wire coil of the same capacity. Considering these facts, when calculating aluminium coils, the conductivity, as compared with that of copper, is to be taken at 1 to 1.5.

These qualities of the aluminium coils, together with the incombustibility of the insulation, will probably also produce an alteration of the standards for dynamos, motors, etc., in that higher temperatures will be permitted for coils of aluminium wire.

As to the manufacture of the coils, the process is very simple. Coils mounted on spools are wound in the usual manner, with the only difference that intermediate layers are placed between the single layers (not turns), which should consist of hygroscopic material, such as asbestos or common hard paper or shirting tape of very small thickness (0.1 to 0.4 millimeter). It is to be especially noted that, in order to prevent the passage of current from one layer to another, the intermediate layers should be a few millimeters wider than the winding of the coil, so as to overlap the end windings by 1 or 2 millimeters on each side. It has been shown that the layer of oxide, forming the insulation of the wire (aluminium oxide being nothing else than argillaceous earth, i. e., the raw material of porcelain) is increased by the action of dampness upon the coil in such a manner that several hundred volts are sometimes required in order to break down the insulating layer. It appears from this that coils used in the open air, such as field coils for electric railway or crane motors, coils of field telegraphs, electric bells, etc., are not affected by the dampness of the air or soil, if made from bare wire, but that such coils will, on the contrary, improve the more they are exposed to dampness.

It has hitherto proved to be a difficult process to solder aluminium wire, so that for each coil a single wire has had to be used. The inventor has succeeded in devising a simple and safe soldering (welding) pro-



The cable as laid on land. The deep-water part of the cable. The underwater cable near the shore.

THE RELATIVE SIZES OF DIFFERENT SECTIONS OF CABLE.

THE PUPIN TELEPHONE CABLE UNDER LAKE CONSTANCE.

Experiments made in the United States for a number of years with aluminium wires for overhead lines, have shown that the objection raised by some parties, that the oxidation of aluminium wire increases constantly during use, has proved unfounded. On the contrary, it has been stated that according to American experience the durability of an overhead line of aluminium will be made (autogenous welding.) No special apparatus is necessary for the use of this process; only a burner flame of acetylene, coal, spirit, or oxygen gas, and a fluid for the purpose of dissolving the oxide coating, that is, for the reduction of the alumina, are required.

* From the Electrical Review, London.

CHEMICAL PROGRESS.

THE WORK OF BERTHELOT, MENDELÉEFF, AND MOISSAN.

WITHIN the past twelve months three great chemists—Berthelot, Mendeléeff and Moissan—have died. In a series of lectures before the Royal Institution in London Sir James Dewar has referred to the work of these men; we abstract portions of his lectures from the columns of our London contemporary, Engineering.

These three men were giants who represented three different types of mind—Berthelot was a colossus, to be compared to Liebig, without any modern parallel; Mendeléeff, the suggestive idealist; Moissan, the pure experimentalist.

Marcellin Berthelot was born in 1827. When engaged in his first research, the study of the constitution of the fats—which are salts or esters of the fatty acids (stearic, palmistic, oleic acids, etc.) and of a trivalent alcohol, glycerin—he did not content himself with decomposing (saponifying) the fats by means of caustic alkali (steam or acids are technically used now to effect the same saponification). This decomposition yielded the alkali salt of the organic acid (a soap) and free glycerin. Berthelot also recombined fats from their constituents, prepared new fats, and further investigated the equilibrium of the reaction. He recognized that the reaction would proceed for a certain time in the desired direction, as decomposition, e. g., but the decomposition would not be complete. When certain proportions—depending upon the presence of water and other substances and on various conditions—had been reached, the action might reverse. Building up a body from its constituents was known as a synthetical process, and these researches led Berthelot to perfect syntheses; that is, the preparation of organic substances from elementary substances—charcoal, air, and hydrogen. Passing alcohol through red-hot tubes, he obtained complex substances; but the alcohol had itself first to be synthetized. The simplest organic acid—formic acid, or, rather, its alkali salt—he obtained from carbon monoxide (CO) and caustic potash; the acid itself should result from the combination of CO and water (H_2O), but these two would not combine.

The formic acid was a starting point. By heating barium formate, he generated marsh gas (CH_4), which further heating, or electric sparking, converted into C_2H_2, C_2H_4, C_2H_6, and higher hydrocarbons, finally, naphthalene ($C_{10}H_8$). The direct combination of carbon and hydrogen gave another starting-point. As these elements would only combine at high temperatures which destroyed the resulting product—acetylene—he passed hydrogen through a bulb in which an electric arc was maintained between carbon electrodes, and withdrew the acetylene at once from the bulb. The demonstration of this very slow reaction was accomplished by cooling and condensing the little acetylene obtained in a U-tube; on warming this tube afterward by the heat of the hand, the colorless hydrogen flame changed into the bright acetylene flame. As acetylene readily polymerized (its molecules unite to form higher compounds), and as it was also easily oxidized, further syntheses opened up. But Berthelot failed, even in his renewed attempts, in the last weeks of his life, to effect a direct combination between carbon and nitrogen in the absence of other elements. He did obtain prussic acid, however, from carbon, nitrogen, and hydrogen. This demonstration was accomplished with the aid of an electric arc in another bulb; and as this acid yielded with water ammonium formate, ammonia could also be introduced into the other synthetically prepared bodies.

While engaged in these remarkable researches Berthelot also placed thermochemistry on a sure basis, working, at first, unaware of the simultaneous investigations of Julius Thomsen (of Copenhagen), and from thousands of observations of the heats of combination of all kinds of bodies, arrived at the conclusion that when two or more bodies react, those bodies will result which, by their formation, produce the maximum amount of energy. The lecturer showed how the Berthelot calorimetric bomb is used. The bomb is a two-part vessel of steel, screwed up, in which substances or mixtures are burned or exploded by chemical or electrical means, after immersing the bomb in a calorimeter. In the demonstration of the complete combustion of an organic substance with oxygen under a pressure of 25 atmospheres, the temperature of the water rose slowly at first, rapidly afterward. Sir James also demonstrated how the velocity of an explosive wave was measured by Berthelot. The two ends of a coiled pipe were bent upward; the gas mixture was fired at one end by an electric spark, and immediately afterward the fiery wave appeared at the other end; the time interval could be measured by a chronograph. The coil used was immersed in liquid air to retard the reaction. In his eightieth, and last year, Berthelot was engaged in studying the heat of hæmoglobin (the chief constituent of the red blood corpuscles), the absorption of carbon dioxide by plants, the heat evolution of radium, and the reactions produced by the silent electric discharge in his (Berthelot) tubes. Berthelot, it will be remembered, was French Secretary of Foreign Affairs for some time.

Dmitri Ivanovitch Mendeléeff was a man who had conducted many series of painstaking studies, but he was essentially a seer, essentially proud, and proud of his having been a seventeenth child; a man of refinement, an idealist, but very careful to verify his speculations by experiments. Mendeléeff first studied crystallography and isomorphism, and then the relations between the pressure p and the volume v of liquids. He recognized that every liquid has an absolute boiling point (the critical temperature of Andrews), above which no liquid can exist as such, and he gave the formula $V_t = 1/(1 - kt)$. This formula was less perfect than the one proposed by an Edinburgh bookseller, Waterston, at the same time; $V_t = a - b \log (T - t)$, where T is the critical temperature; but the papers which Waterston sent to the Royal Society were not heeded until Lord Rayleigh had them published later.

Mendeléeff then turned to gases. That the $p\,v$ could not be constant was clear, since that meant that finally the gas could not occupy any volume at all. Hence Mendeléeff argued, there must be a minimum volume for a gas, and similarly a maximum volume; that is to say, a gas will not at any reduced pressure expand to an unlimited amount. That the first part of the argument was correct is proved by the work of Regnault, Amagat, and Andrews on the $p\,v$ curves, which, as Mendeléeff foreshadowed, all became finally straight parallel lines, while at first there was a decrease in the $p\,v$ for all bodies (with the exception of hydrogen, whose $p\,v$ was a straight line from the beginning). But the latter argument, the upper limit of expansion which Mendeléeff attempted to demonstrate by experiments on a big scale, we do not now believe to be correct. These researches brought Mendeléeff to a study of the atmospheric circulation. Having visited the petroleum wells both at Baku on the Caspian, and in the United States, he recognized the broad difference in the composition of the two natural oils, and expressed the opinion that while the American oil, which seemed to be confined in relatively small natural reservoirs that were soon exhausted, might be of animal origin, the Baku petroleum was probably the product of the decomposition of metallic carbides, of which we knew very little in those days.

Passing to the periodic law, with which Mendeléeff's name will remain pre-eminently coupled, classifications of the elements had been based by Dumas and others on the striking analogies presented by oxygen, sulphur, selenium, and tellurium, and their compounds, and by other families of elements. Following unknowingly in the wake of Newlands, Mendeléeff—and Lothar Meyer similarly at the same time—arranged the elements in twelve series of groups of seven or more elements, according to increasing atomic weights. The task was far bolder, Sir James said, than it appeared to-day; for the constants of the elements, which he regarded as periodic functions of the atomic weights, were less perfectly known then. Yet three lacunæ in the table were soon filled up, as predicted by Mendeléeff, by the discovery of three new elements (scandium, gallium, and germanium), and his corrections of several atomic weights which did not fit his table were proved to be justified. Mendeléeff, Sir James stated, was not easily disturbed in set views. The rare earths were accommodated in his table, and room was found for the new gases as well by placing helium, atomic weight 4; neon, 20; argon, 40; krypton, 82; and xenon, atomic weight 128, at the heads of the old groups. In one of his latest speculations Mendeléeff suggested a chemical conception of the ether as a legitimate extension of his periodic law. Two more elements remained to be discovered, one of atomic weight 0.4 (hydrogen = 1), the other lighter even than the corpuscles or electrons, a kind of neutral substance that would not be attracted by the sun.

Henri Moissan was born in 1852, at Paris. To Moissan belongs the credit of having rejuvenated inorganic and mineral chemistry in our age of organic chemistry. A pupil of Frémy and Deville—both famous inorganic chemists by the way—Moissan first studied the evolution of oxygen and of carbon dioxide by plants in the dark, investigated the oxides of the iron metals, and then took up the isolation of fluorine, which so many distinguished experimenters had tried before him. The alchemists knew that sulphuric acid attacked fluorspar, and generated from it a gas which corroded glass; the electrician Ampère first pointed out the analogy between hydrochloric and hydrofluoric acids. Kemp made vessels of fluorspar for the acid, which is now kept in paraffined bottles. Moissan electrolyzed perfectly dry hydrofluoric acid in a U-tube of copper (originally platinum was thought indispensable), with plugs of fluorspar for the platinum electrodes, and two outlets, the one for the hydrogen, the other for the fluorine. The fluorine gas passed through a coil which, like the U-tube, was immersed in solid carbon dioxide to condense the fluorine, and through two tubes filled with sodium fluoride to absorb traces of the gas. The gas had a faint greenish-yellow color, and attacked almost everything; finely-divided carbon burned in the gas, forming a compound analogous to carbon tetrachloride (CCl_4), colorless liquid, which we could not prepare synthetically out of C and Cl, however. That fluorine formed a similar volatile compound with silicon was shown with the aid of some fluorine gas inclosed in glass pipettes, sent by Prof. Lebeau—Moissan's former assistant in these and other researches. The perfectly dry gas did not attack glass.

Dwelling on the analogies between fluorine, chlorine, bromine, and iodine, which form the so-well-characterized group of the halogens, Sir James showed that chlorine gas could easily be condensed to a yellow solid, and bromine to a red solid. The melting points of the four elements were in deg. Cent.: F —215, Cl — 102, Br — 7, I + 114; the boiling points in the same order, — 187, — 33.6, + 58, + 184 deg. C.; the specific gravities, 1.14, 1.56, 2.95, 3.38; and analogous gradations were found to hold for the atomic weights, 18.91, 35.74, 79.84, 125.89; the atomic volumes, the atomic refractions, etc. Again, a similar gradation was observed in the properties of the compounds, except that the boiling point of hydrofluoric acid (+ 19.4 deg. C.) was too high, probably because this acid polymerized. A study of the physical and chemical constants of certain organic (benzene) compounds of fluorine had, however, misled chemists in ascribing to fluorine a higher volatility than to hydrogen; fluorine could be condensed at about —215 deg. C., as mentioned already.

The enormous activity of fluorine was marked by the number of heat units liberated—according to Berthelot—when fluorine and hydrogen combined to hydrofluoric acid (HF)—viz., 38,600—while the formation of HCl only liberated 22,000 heat units. Now solids hardly reacted on one another under ordinary circumstances, and we had every reason to believe that at absolute zero temperature all reaction must cease. As, however, fluorine still attacked the hydrogen of organic compounds when they were kept in liquid air, Moissan had doubted that fluorine would really become inactive at the lowest procurable temperatures. In 1897, therefore, Sir James Dewar and Mr. Lennox tried whether fluorine could be solidified, and how it would behave then. The fluorine did freeze at 20 deg. or 30 deg. absolute; but when liquid hydrogen was dropped on the solid, the whole apparatus was shattered to fragments. We thus had a proof, at any rate, that fluorine was the most active body.

With graphite, however, fluorine only combined when the graphite was red-hot, with diamonds not at all. But graphite, and not diamond, was the most stable modification of carbon at high temperatures; and as minute diamonds had been found associated with other carbon, in meteorites, Moissan started on his preparation of artificial diamonds by melting iron and carbon (carbonized sugar) in a crucible, and dropping the fused mass into water. The iron would expand on solidification, and the chilled outer crust would subject the still liquid solution of carbon in iron inside to an enormous pressure. Sir James mentioned Moissan's preparation of the hydrides of potassium (KH), cæsium, and rubidium—snowy crystals, representing alloys of the metal and hydrogen, which did not conduct the electric current any more than hydrogen did—and to the many products which Moissan prepared in the electric furnace. Of the carbides, those of lithium, calcium, strontium, and barium yielded on decomposition with water, acetylene C_2H_2; aluminium carbide gave marsh gas (CH_4); manganese carbide yielded CH_4 and hydrogen; the carbides of the rare earths cerium, yttrium, thorium yielded C_2H_{22}, CH_4, ethylene C_2H_4, and some liquid paraffins; while the carbides of chromium, molybdenum, titanium, and zirconium were not decomposed by water, so far as it had yet been discovered.

It is reported that in 1908 Canada will make her own coinage, amounting to sixteen or twenty million pieces annually. The Royal Mint in London now coins sixteen million pieces for Canada per annum. When the new Canadian Mint opens, probably in December next, one or more new coins will be issued. A new two-cent piece will be coined in nickel. This will be the first time that nickel has been used in Canadian coinage, although it is one of Canada's mostly largely produced minerals.

THE LEFT HEMISPHERE OF THE BRAIN.

ITS INFLUENCE ON THE USE OF THE ARMS AND HANDS.

BY DR. H. LIEPMANN.

THE discovery, made by Broca about forty years ago, of the connection between the power of speech and the left hemisphere of the brain is properly regarded as one of the most important contributions ever made to our knowledge of the mutual relations of body and mind. It was the first instance of the localization of a mental function in a definite area of the brain. That the aphasia, or loss of the faculty of intelligent speech, which follows serious injury to Broca's convolution is not due merely to paralysis of the vocal muscles, is evident from the fact that the ability to write and read is also more or less affected. Hence it may be inferred that a person thus afflicted—with motor aphasia, to use the technical term—has to some extent lost the memory for words, for if the muscles employed in speaking were alone affected, the patient should still be able to write words, and to recognize written and printed words.

But only a part of the memory of the word is lost, for the patient still understands what is said to him. The memory of the sound of the word remains intact, but the memory of the muscular movements required in articulation is gone. The latter is that part of the verbal memory that is built up in childhood by continual practice in enunciating words and which makes possible the knowledge of the syllables and letters of written language.

Ten years after Broca's discovery, Wernicke studied a patient afflicted with sensory aphasia, that is, one who could not understand spoken words, and traced the difficulty to an injury of the left temporal lobe of the brain. The memory of the sounds of words was thus localized in the left cerebral hemisphere.

There are still many mooted points in the theory of aphasia, which has been built up by the labors of numerous physiologists during the last half century, but one fact, at least, is universally recognized—the great predominance of the left hemisphere of the brain in controlling the function of speech.

The study of other motor phenomena of complex character was long neglected. The theory of paralysis and cramps of the limbs was developed and, later, that of a more special motor disturbance, ataxia, which is betrayed by sudden, convulsive and ineffectual movements. It was observed, also, that many persons suffering with brain diseases, though free from both paralysis and ataxia, performed many absurd actions, such as using a tooth brush, for example, as if it were a cigar. This condition, to which the name apraxia was given, is often the result of mistaking one object for another, and it was generally attributed entirely to this cause.

In 1900 I had occasion to observe a very peculiar case. The patient had no paralysis and he recognized objects perfectly, but he used them improperly. His gestures of greeting, threatening, beckoning, and other actions in which no objects were employed were equally grotesque. To this condition I prefer to give the name apraxia, while I designate as agnosia that perversion of actions which is caused by failure to recognize the character of objects.

In apraxia, as I define it, the patient is unable to move his hands and other members so as to perform acts properly, that is, he cannot make them obey his will. The most striking phenomena of both diseases may be comprised in the statement that the ability, acquired during life, to make various purposeful movements has been lost, either because the movements have been forgotten or because the muscles cannot be induced to execute them. The arm and leg muscles are affected in apraxia much as the muscles of speech are affected in aphasia. In both cases the muscles have not lost their mobility but the co-ordination of impulses required for the performance of a complex action has become impossible.

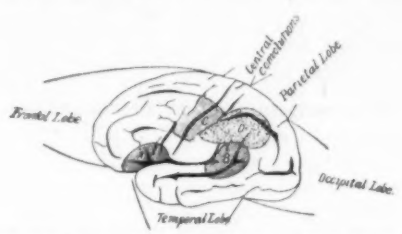
My patient of 1900, like many other apractics, had lost the power of speech. Only the right half of the body was affected with apraxia to any great degree. With his right hand he did almost everything wrong. He would stick a comb behind his ear as a pencil is often carried, wipe his nose with a handkerchief in which he had been asked to tie a knot, and grope wildly in the air in the attempt to remove his eyeglasses. But when the right hand was held, so that he was compelled to use the left hand, he did almost everything correctly. He could even write fairly well with his left hand, though the letters were reversed. This proved that he understood commands and recognized objects and consequently that he could decide to perform the acts requested, but that he could not control the right half of his body. This right half behaved like that of an idiot, but the man was not an idiot. Nature had performed an exceedingly instructive experiment on the poor fellow, and I studied him very attentively during the two remaining years of his life.

My conjecture regarding the character of the brain lesion was confirmed by the autopsy. The nerve center which controls the right arm and leg, and which is situated in the left hemisphere of the brain, had been deprived, by a process of fatty degeneration, of its many natural connections with the centers of sight, hearing, etc., in both hemispheres. Hence the directive impulses which are normally sent from the various special sense centers to the hand center were transmitted imperfectly or not at all.

I and other physiologists soon discovered many other cases of apraxia which differed greatly in detail. It was found that apraxia is as common as aphasia in diseases of the brain, and that its study gives an insight into the dynamics of cerebral processes and the psychology of the most important phenomena of life. It is especially interesting because it is intimately related to certain phases of insanity and because the explanation of the mechanism of elementary acts brings us a step nearer to the understanding of the higher abnormalities of conduct which we observe in the insane and which are not directly connected with apraxia.

The recognition of the condition of apraxia also leads to other results. For the benefit of non-medical readers I will premise that the right half of the body is governed by the left cerebral hemisphere and the left half of the body is governed by the right cerebral hemisphere. For example, an electrical stimulus applied to a certain region in the left hemisphere produces contraction of the right arm and leg. Such a region is called the "center" of the member or function which it governs. Paralysis of the right arm is produced by serious injury to the arm center in the left cerebral hemisphere, and conversely.

Now my observations of more than 150 cases of



THE LEFT HEMISPHERE OF THE HUMAN BRAIN.

A. Motor center of speech. B. Sensory center of speech. C. Arm and hand center. D. Region of the parietal lobe, injury to which produces apraxia.

brain disease have led to the following remarkable results. Those patients whose left arms had been paralyzed by lesions in the arm center in the right cerebral hemisphere could use their right arms and hands as well as ever. But about half of those patients whose right arms were paralyzed had more or less completely lost the power to use their left hands, except for such common and simple operations as conveying food to the mouth, buttoning garments, etc., which nearly all of them contrived to accomplish with their left hands. Only about half of these persons with paralyzed right hands could use their left hands successfully in beckoning, threatening, or other expressive gestures, in turning a crank, knocking on a door, counting money or writing down figures from memory. Some went badly astray in handling objects. One patient set his eyeglasses on his protruded tongue instead of his nose, another in trying to seal a letter put the hot sealing wax in his mouth, a third put a match between his lips, like a cigarette, instead of striking it, etc. Attempts to imitate the actions of other persons were equally unsuccessful and often ludicrous. In short, the left hands of these persons with paralyzed right hands were more or less affected with apraxia, which in many cases was revealed only by special tests like those mentioned above.

The degree of this partial apraxia, or dyspraxia, of the left hand, was not a matter of chance, but was found to increase with the proximity of the seat of disease to the cortex of the brain and the number of interruptions in the connections between the cortical layers of the right and left hemispheres.

This dyspraxia of the left hand may occur when the right hand is not paralyzed, but only apractic, and even when the right hand is entirely normal. In the last case those connections between the hemispheres that traverse the so-called corpus callosum are interrupted, as has been proved by series of sections of the brains of three persons so affected.

These facts explain the slight but unmistakable symptoms of apraxia observed in the left hand of my first patient, who had complete apraxia of the right side of the body, and they give us a new insight into the relation between the cerebral hemispheres. We knew that the right arm and hand are usually stronger and more skillful than the left, but we believed that the left hand was governed entirely by the right brain. We see now, however, that the left brain exercises a sort of suzerainty over the right brain in regard to many of the powers of the left hand. The right brain is dependent upon the left brain for the memory, design, and performance of complicated movements executed for specific purposes. Certain regions of the left hemisphere are already known which govern both conscious and unconscious preparation for action. If these centers are injured or if their connections with the right brain, by way of the corpus callosum, are broken, the right brain is left without a leader and betrays its incapacity to direct the delicate work of the hand.

It appears, then, that the left hemisphere predominates in the government of the hand as it does in that of speech, though to a less degree and, probably, with greater individual variations in degree.

In addition to distinctly left-handed persons, who constitute four per cent of the population, there is a yet unknown number of ambidextrous persons who form exceptions to the rule that the functions of speech and language are localized in the left brain, and it is probable that the exceptions to the localization of the functions of the hands in the left brain are still more numerous. The independence of the right hemisphere in this respect will be conditioned by the capacity and education of the left hand and therefore of the right brain. This factor and the situation and extent of the brain lesion determine the degree to which the utility of the left hand is impaired by diseases of the left brain.

Many ingenious explanations of the predominance of the left hemisphere in the control of speech have been suggested, but the problem has not been completely solved. That this predominance is associated with right-handedness has been known since Broca's researches. To me, the predominance of the left hemisphere in directing the hands appears to supply a connection between right-handedness and the localization of speech in the left brain. The functions in which the insufficiency of the right hemisphere is most strongly marked are concerned with actions which depend on memory and are not suggested by the sight and contact of material objects. We have seen that in most cases the incapacity of the left hand is most evident in actions of this character. Now, speech is such an action. In chewing, the muscles of the tongue, lips and jaws are stimulated by contact with food; but in speaking no such material stimulus is present, and the control by the ear is not exercised until after the action has commenced. Hence we may group the peculiarities of speech and manipulation together in the statement that the right brain is especially unfitted for the conduct of actions that are wholly remembered and not at all suggested by material objects.

Another step in advance could be taken if we could accept Max Müller's synergastic or co-operative theory of language, which regards verbal roots as sounds which, in the infancy of civilization, were habitually uttered by numbers of men engaged in rowing, hammering, pile-driving, etc. If the first words of primitive man were such rhythmical accompaniments of arm and hand movements which, as we have seen, are directed chiefly by the left brain, the fact that the production of speech is governed by neighboring regions of the same hemisphere becomes less astonishing. I advance this hypothesis with some diffidence as I do not know how much vitality is retained by the co-operative theory which, I believe, has been abandoned by the majority of philologists.

A practical conclusion may be drawn from the facts described above. The exercise and education of the left hand have already been recommended on various grounds, but principally for the reason that two skillful hands are better than one. But there is a stronger reason. Concepts of motion form the basis of all our concepts of space and constitute an essential part of that which we call intelligence. The idea that the co-operation of an educated right brain with the left brain may increase the precision, permanence, and availability of our spatial concepts and thereby improve our intellectual ability in general, is, at least, worthy of consideration.

We find, furthermore, no difference between the cerebral hemispheres in animals, even of the highest species. Monkeys and apes are ambidextrous and there is no one-sidedness in the talking parrot. The superiority of man to brute is associated with an accumulation of special faculties in the left cerebral hemisphere, but it is due to the positive improvement of that hemisphere, not to the mere fact of inequality or the undeveloped state of the right brain. It is con-

ceivable that in a more advanced stage of human evolution the right hemisphere may be able to relieve the left of the government of the hands and tongue and leave it free for the exercise of still higher functions, the advent of which is expected by all believers in the theory of evolution.

To return to the present and immediate future, the study of apraxia will give us a deeper insight into the psychology and physiology of manual action and the dynamics of cerebral processes. Anatomically, no definite center controlling the actions here considered appears to exist. They seem to depend upon the harmonious co-operation of many parts of the brain with the hand and arm center in the left hemisphere. This center and its immediate vicinity are consequently of paramount importance, especially the region behind this center, traversed by the principal connections between the center and the temporal and occipital lobes of both hemispheres. Lesions in this region are the most conspicuous in practice because injury to the arm center itself usually causes paralysis, by which the apraxia is masked. Hence the commonest cause of apraxia is a lesion in the left parietal lobe of the brain. The eventual partial compensation will depend on the condition of the corpus callosum and other connections. It has already been pointed out that the usefulness of the left hand, in particular, depends upon the integrity of the corpus callosum as well as upon that of the left brain area under consideration. —Umschau.

PHOTOGRAPHING CAPTIVE STARFISHES.

INTERESTING NOTES FROM A PACIFIC STATION.

BY CHARLES F. HOLDER.

Some extremely interesting experiments have been made at the Santa Catalina zoological station illustrating the tameness of certain marine animals. The aquarium at this point makes no claim to a fine building or arrangement of tanks, its value being in the possession of rare and interesting animals of the sea to be seen nowhere else. The Pacific coast fauna has a certain resemblance to that of Naples. It is semitropic, the region lying in the Black Current of Japan, which sweeps down the coast; hence it receives visitors from many climes, being, as it were, a neutral zone.

THIS PHOTOGRAPH CLEARLY SHOWS THE STRANGE COLORING OF THE UPPER SURFACE OF THE STARFISH.

Among the interesting animals to be seen here are a variety of starfishes varying from the giant shown in the accompanying illustration to minute forms almost invisible to the ordinary observer. An effort is made in the aquarium to give the various animals in confinement a home identical with that from which they were taken, the result being attractive marine pictures, giving the observer an accurate idea of the appearance of the ocean in the splendid beds of seaweed that characterize these shores. When the gigantic starfish was taken from the water the collector carried the surroundings in his mind and made up the tank with a view to reproducing as near as possible the conditions which held in the location of its choice.

The starfishes are lowly creatures, but extremely interesting, and when on good terms with one like the large one shown a good opportunity is afforded to study its habits. This specimen is over twelve inches across, a massive, unwieldy creature; its lower section, as shown, is a light flesh color, the opposite a rich brown, covered with compressed tubercles or spines, the central portion rising in a dome shape. In a general sense the animal is inconspicuous, its colors blending with those of the weed. Its enemies are two sharks, the puff shark, and the California Port Jackson shark, which affect similar situations and are often coiled up in the rocks after having feasted on the large starfish.

The big star, while a simple animal and very lowly, has a complicated structure, a very good idea of which is seen in the photograph which shows the under side, the animal evidently being made of a multitude of limy plates, all of which appear to be arranged around a common center, the mouth. There is a pronounced "radiate symmetry." There are five radiating arms, and down each is seen extending a groove, and along each side of this, like plants along a highway, are curious tubular feet that cling to the rocks or glass, each having a sucker. These are continually thrown out in the direction the starfish wishes to go, fastened to the glass, and by these kedge anchors the star is pulled along, the others breaking away as it moves. If the end of each ray is examined, a spot supposed to be the eye is seen, and as there are five rays, each has an eye, one of the latter being always in advance.

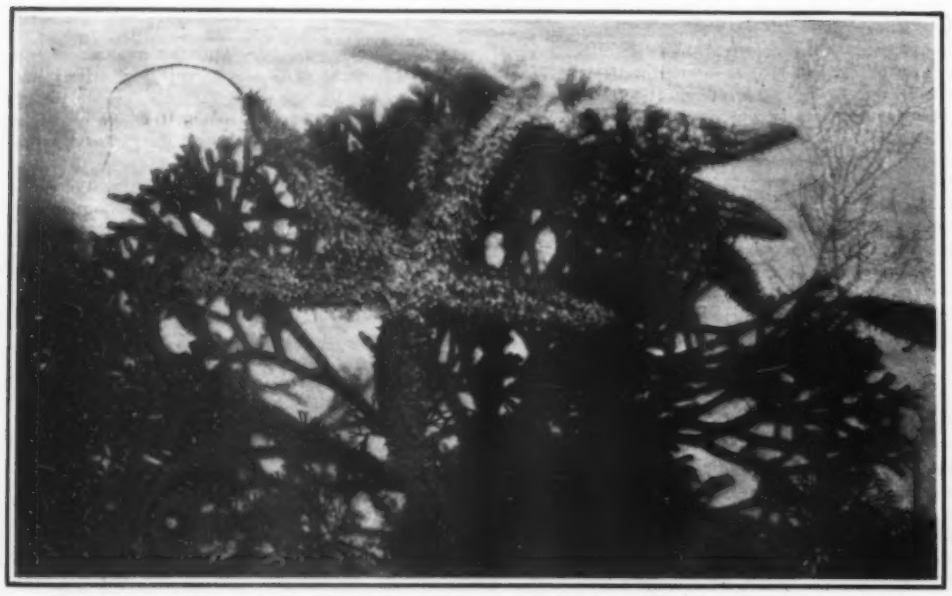
This eye is not a very keen organ. At least in numerous experiments which I have tried, the starfish could not be intimidated by the appearance of strange objects in the water. Its sense of smell was doubtless the most important, and the big star shown would move over my hand to reach a piece of fish when hungry, displaying no fear.

On the back of the starfish, which may be brown, red, pink, or lavender, is a thick skin which appears to be drawn over the framework and filled with spine-like projections. Between these are other little transparent bodies, resembling bags, filled with water and supposed to have something to do with the breathing or respiration of the animal. Watching the upper side, we see a little red disk near the center upon one side. This is a sieve pierced with minute holes, and like a cap covers the entrance to a tube which leads down into the starfish, where it finally reaches the mouth and encircles it. This encircling tube has several radiating tubes which connect with the sucker-mounted feet we have seen in the grooves along the arms.

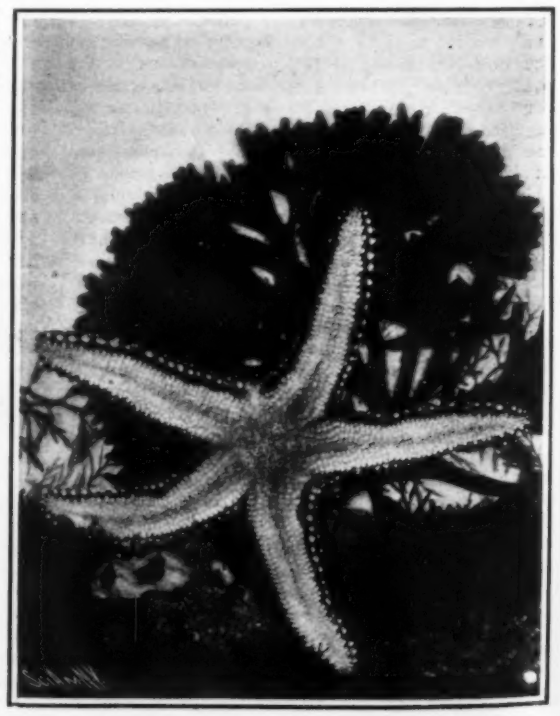
It is very possible that the man who first packed a filter with sand to clear water had examined a starfish, as the little stone tube is the filter of the starfish. The tube contains sand, and the process is as follows: Water passes through the sieve or madreporic plate down through the tube, where the sand tends to purify it; then into the tube about the mouth; then reaching the hollow feet, which become gorged with it. This is what is known as the water vascular system of the starfish. When the starfish is dormant the hollow feet may not be filled, but the moment the feet are projected from the groove the little bags that connect the water tubes contract and force water into them, and each minute leg or foot becomes filled and is pressed upon the glass, just as a boy presses his wet leather pad to lift a stone.

Our big starfish is very neat and cleanly in its habits. The surface is covered by groups of little hand-like objects that are continually opening and shutting and whose office is to remove sand or bits of weed that fall on it. This explains why starfishes are always so free from outside objects. The moment a particle of offensive matter falls on it, the latter is seized by the little hand, passed to another, and so dropped over the edge.

In this aquarium are starfishes in all stages of mutilation. Some have lost one arm, some two, and others have been robbed of all by some predatory fish. Such wholesale depredations might annoy some animals, but not the starfish, as we see new arms growing out and in all stages of development. Even if cut into several parts the starfish is able to recuperate and in a few months reproduce itself or all its parts. The



SMALL STARFISH WALKING, SHOWING THE DORSAL AND VENTRAL SURFACES AND THE "FEET" IN ACTION.



THE UNDER SIDE OF ONE OF THE GIANT STARFISH OF SANTA CATALINA.

large starfishes in this aquarium are tame, that is, they will eat from the hand. The ray approached is raised slightly, that the little eye with its myriad of crystal lenses may be directed at the stranger, then it moves on and rapidly takes the food. A large oyster, despite the fact that it requires all the muscular force of man to pry it open, has but little chance with this star, which encompasses it and throws out a part of its stomach and literally covers it, and the oyster is either suffocated or killed by the juices of the starfish. In this way starfishes all over the world play havoc with oyster beds, in a single day wiping out thousands of dollars, so that oystermen adopt various devices to drive them off, some using piles of tin as a "scarecrow," believing that the starfishes are afraid of the glistening mass. The rapidity with which the stars move is well illustrated here. When a photograph was taken it was necessary to make a very quick exposure or the starfish would move. They flee from extreme light and attempt to hide themselves in cracks and crevices; but I found that I could lead a hungry starfish all around the tank by making it follow a bait.

The development of the young has been observed here. The eggs in a short time change into strange free-swimming bodies which float about, and would not be taken for starfishes by the uninitiated; but they soon drop to the bottom and assume the shape of the adult.

The starfishes are valuable scavengers, eating dead animals of all kinds, and may be classed among the valuable purifiers of the sea. In this collection are seen brittle stars in rich tints, feather stars, and a remarkable variety in shape and color.

THE DISCUS THROWER OF CASTEL PORZIANO.

THE PROBABLE APPEARANCE OF A FAMOUS STATUE.

Of the famous bronze statue of the Discus Thrower, the work of the Greek sculptor Myron, a contemporary of Phidias and Polycletus, many marble copies were made by Greek and Roman artists. Several of these copies are still in existence, the best known being those of the Vatican, the Capitoline museum, and the Lancellotti palace in Rome. The last-named statue is guarded so jealously that no visitor has been allowed a glimpse of it in many years

Fragments of another marble copy of Myron's famous work were discovered in July, 1906, among the ruins of a Roman villa of the imperial period on the royal estate of Castel Porziano on the shore of the Campagna between the sites of the ancient cities Ostia and Laurentum. The reunited fragments, fourteen in number, have been presented by the King of Italy to the National Museum. Although the mutilated statue is headless and lacks both feet, the right arm and the fingers of the left hand, it was at once recognized as a work of great excellence, little inferior to the Lancellotti statue and surpassing that of the Vatican in fidelity to the original and in artistic value. Prof. Rizzo, the director of the Museo Nazionale, has made use of the head of the Lancellotti statue, the feet of the Vatican copy, and an arm holding the discus preserved in the Buonarroti gallery in Florence in a restoration of the newly-found Discus Thrower, which reveals the full beauty of the work and the characteristics of Myron's style.

The artist, according to his custom, has chosen the moment when every movement is directed toward one point and the muscles of the thrower are as tense as the cord of a drawn bow. The heavy discus is held as far back as possible in order to increase the effect of the throw. In the next instant the right hand will fly forward in an arc of a circle and launch the missile on its course, and the body will assume an attitude contrary in all points to that of the statue. The left foot, now slightly retracted, will dart forward and support the weight of the body, which now rests wholly on the right foot. The latter will rise on its toes, the left arm will swing backward, the body will be extended to its full height, the head raised, and the glance, now fixed on the discus, will be suddenly directed forward to follow it in its course.

On comparing the newly-found Discus Thrower with the Vatican statue, it is evident that the head of the latter—which is a modern addition, as this statue was also found in a mutilated condition—is wrongly placed. It should be turned more to the right, like that of the restored Castel Porziano statue, in order to gage the motion of the arm.

The lightness and vivacity of the original bronze are lost in the reproduction in marble, as this material makes necessary the introduction of the tree stump and other supports, of which fragments are still visible in the mutilated copy. The crude force of the archaic Myronic style is visibly weakened in the marble copy. The latter is, nevertheless, a great work of art and a valuable acquisition to the Roman museum. The material of the statue is marble from the Greek archipelago. Its height, measured from the plinth to the deltoid muscle of the right arm, is 58 inches. Hence it is slightly larger than life size.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the Illustrirte Zeitung.

THE DISCUS THROWER.

The mutilated statue found at Castel Porziano in 14 pieces, flanked by its restoration (on the right) and the Vatican statue, another restoration of a fragmentary work (on the left).

EXCAVATIONS OF M. DE SARZEC IN CHALDÆA.

THE UNCOVERING OF AN ANCIENT GRANARY.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

M. DE SARZEC, an eminent French archæologist, has been engaged in making excavations on the site of some of the ancient cities of Chaldæa. In this he met with great success, and the result is a number of interesting finds which cover four different epochs of Chaldæan history and go as far back as 4000 B. C. But some of the excavations have brought to light buildings and different objects which are still more ancient.

Most of the work has been carried out at Tello, which is the site of the ancient Chaldæan city of Sirpourla. The ground is dotted with *tells* or mounds, each of which covers an ancient building. Upon uncovering one of these mounds, M. De Sarzec came upon the remains of no less than three buildings or palaces, lying one above the other and belonging to three different epochs. The remains of the lower structure served as the foundation for the second, and this in turn for the upper one. As to the upper structure, but little of it remains. It appears to have been erected at the epoch of King Gudea (between the twenty-fifth and thirtieth centuries B. C.), as the sanctuary of the divinity Nin-Ghersou. Below this structure is one which is considerably older, and belongs to the epoch of Ur-Nina, or about 4000 B. C. This is a rectangular building measuring 35 by 23 feet. It is built of oblong and convex brick, cemented with bitumen. The bricks are convex upon the upper surface only, and have an inscription of Ur-Nina and a thumb-mark in the center which occurs on many of the bricks, and may have been a sign that the brick had passed an inspection.

The construction stands upon a base or paving formed of three layers of flat brick, laid at the level of the soil. This base marks the starting point of the present building, and is the limit of the epoch of Ur-Nina. As to the walls of the structure, they are about two feet in thickness and are built of flat brick in three ranges, the brick being laid after a somewhat complicated system, so that the joints are covered in each case. Some surprise was caused by the fact that there were no openings or doors to be found on the four sides of the building, and it could not be entered from the ground level for this reason. It must have been entered from the top, and air and light had to come in the same way, but as the top of the structure does not exist, this feature is left to conjecture. At any rate, it could have hardly been a dwelling house or palace of the ordinary kind. In order to enter it, some kind of staircases must have been used. These may have been of light brick or of wood, and they were no doubt designed to be detached from the building if need be, so as to protect it to some extent. The building may have been a treasure house, or storehouse of some kind, perhaps for grain to a large degree. We have examples of Egyptian granaries in paintings and even in relief, and there are no doors, but an opening in the roof, with a staircase on the outside which seems to be removable. The inside of the structure is no less curious, and indicates a special destination. Around the building runs an inside wall, which is separate from the other, forming a rectangle and leaving a space or hall about three feet wide all around. A similar passage runs across the building, dividing it into two unequal parts. There is thus no contact between the inner and the outer walls. Inside we have thus a large square chamber and a narrower one, and no doubt these were not inhabited, but used for storage. Grain, for instance, could be well preserved here. The double walls would give a good protection from heat and moisture, also from animals or insects. The grain could have been poured in from openings in the ceiling and the chambers would be easily filled up. Here might have been stored the seventy great measures of wheat mentioned in an inscription of Ur-Nina, or the spoils of war coming from his successors, reserves of weapons or all kinds of valuable objects. The walls and flooring are carefully covered with a coat of bitumen, no doubt for greater preservation.

A small number of objects dating from the epoch of the ancient kings were found here. On the outside of the structure is seen a somewhat remarkable disposition. The building is surrounded at a distance of twelve feet and on the level of the paving by a series of eight supporting points, two opposite each side of the building. Each of the supports is formed of four square brick about one foot square, making the whole two feet square. The brick are laid together upon a base of bitumen. M. De Sarzec found some debris of charred wood belonging, no doubt, to pillars which had been set up on the bases of brick. The posts are about twenty inches square, and one specimen is long enough to give an idea of the construction, this being a well-squared cedar post. No doubt they served to support a wide gallery or portico which ran around the building, but this was of a very primitive nature. Perhaps there were intermediate supporting posts between the others, placed on the ground or upon pillars of raw brick. This gallery was no doubt added afterward and renewed at different epochs, as the bricks do not seem to be of the same date.

At one end of the structure there was a brick paving

of the same width and extending out for thirty feet or more. It is made of square brick of medium size interspersed with smaller ones in irregular form, no doubt having been repaired. On the other side of the building is a small basin of brick of nearly square form, five feet square. It is lined with bitumen and is divided into two parts by a cross partition, and may have been used for successive washings. Not far off are two other basins of larger size, perhaps the Abzu-Gal or great reservoirs, mentioned in the inscriptions. They are built of convex brick like those of the main building, and are coated with bitumen inside. One of them is six feet square and three feet high, and is placed against a mass of coated brick which forms a flat platform on a level with the top of the basin, no doubt to receive the water pots or other utensils, or for garments or fabrics which were washed here. Near by are the remains of a drain, which is laid along the ground in coated brick, leading for 45 feet, then turning off at an angle for about the same distance.

Most of the interesting finds of the epoch of Ur-Nina were found outside the main building, but not far from it. Among these is a slab with reliefs of Ur-Nina and the remarkable Vulture-Stele, both of which we have illustrated in a preceding account, also a mortar of Enannatuma I. and the stone head of a war club with figures of lions in relief. A bronze lance head of unusual size is another of the objects found here. The building may have had a top story, which contained the sanctuary of the divinity of Nin-Ghersou and the goddess Nina, placed upon the treasure house. Inside the building were found a number of stone slabs with inscriptions of Ur-Nina, and lance heads which showed that arms may have been stored here.

Lying below the first building is a second building which presents a great interest as being perhaps the oldest specimen of Chaldæan architecture as yet brought to light. When the above-mentioned structure was erected, the ancient building was used to form part of the foundation, and the whole was filled up and then leveled off for the purpose. M. De Sarzec accordingly removed the top building and proceeded to explore the more ancient one underneath. After having uncovered it entirely he found it to be an oblong structure twenty-five feet long and twenty feet wide, being smaller than the first one. It is built of convex bricks, but there is no inscription, so that the edifice is anonymous. At the base of the walls is a good pavement of gypsum slabs two by four feet, and what is remarkable is that the walls are surrounded to three-quarters of their height by a solid mass of considerable thickness, built of brick alternating with gypsum slabs, cemented with bitumen. The structure thus appears to be imbedded in the solid mass which surrounds it on all sides and forms a rectangle. As to the plan of the walls, they are also laid out in a rectangle, with a door at each end. There is a cross wall which divides the building into two unequal parts. In the smaller one, the floor level lies as high as the surrounding outer mass, while in the second the floor is formed by the foundation paving. This edifice is anterior to the epoch of Ur-Nina. A few objects were found here which represent the most ancient period of Chaldæan art. One of these is a flat cylinder which seems to have formed the top of an altar. Around the edge are figures in relief. Two of these appear to represent a chief bearing a lance, and facing him a king with a bent scepter and wearing a tunic. The names are broken off. A number of votive figures of bronze were also found, which terminate in a point at the lower part. Another object is the bottom of a stele which represents a procession, no doubt of warriors. M. de Sarzec expects to make further important discoveries.

THE COLZI SUN PRISM.*

A DEVICE FOR CONTROLLING LIGHT INTENSITY.

BY DR. ALFRED GRADENWITZ.

A SPECIAL difficulty experienced in connection with sun observations is due to the great amount of light and heat concentrated in the image. This drawback is generally remedied by means of colored or smoked dark glasses, which, however, alter the sun's colors. Devices which picture the sun in natural colors are costly, and only imperfectly remove the effects of the heat.

When ordinary smoked glass is used, the heat under certain conditions becomes so intense, that the glass is cracked and even fused. Sometimes the eyes are injured. Stopping down the objective results in a loss of fine details.

Father Colzi of Arezzo has recently devised a sun prism, free from these disadvantages. His prism shows the sun directly in enfeebled, but natural light in the same situation as in astronomical telescopes—not reversed—rendering observations possible in the direction of the axis of the telescope.

The accompanying line drawing shows the construction of the sun prism, which consists of two parts, viz.: (a) the mirror *S*, and (b) the heterogeneous double prism *P*.

The mirror *S* serves to reflect from its unsilvered surface a small portion of the sun's rays. The greater part of the light and heat pass straight through the glass plate to be reflected by the small glass mirror *Q*. To avoid images, the mirror *S* is either polished slightly wedge shaped, or, as suggested by Colzi, a simple plane-parallel plate may be used, the back of which is very finely etched or ground. Experience has shown that no illumination of the field of vision need be apprehended.

The heterogeneous double prism *P* serves the purpose of controlling the intensity of light emanating from the mirror *S*, which being still much too strong for direct observation, should be moderated to a degree corresponding with that of the full moon.

The double prism *P* comprises an ordinary totally-reflecting crown-glass prism *B* and a fluid prism *C*. Without the fluid prism *C* the prism *B* would produce merely a total reflection of the rays which are deflected by the mirror *S*, without mitigating their intensity. If, however, a fluid of somewhat different refractive index be poured upon the hypotenuse, total reflection, owing to the slight difference between the two refractive indices, is eliminated and—according to the difference of the refractive indices between glass and the fluid—more or less of the incident light is reflected upon the eyepiece. By choosing a suitable fluid, the intensity of the light reflected from the hypotenuse surface may be accurately controlled. When the glass and the fluid have the same refractive index, the two prisms actually form a plane-parallel plate, no light reaching the eyepiece.

Various oils, whose refractive indices differ but little from the index of the glass prism, can readily be used. A slight coloration of the fluid entails no disadvantage. In order to make the fluid chamber perfectly tight, to compensate for the thermal expansion of the fluid, as well as to permit whatever sunlight is transmitted through the hypotenuse surface to pass out of the sun prism, the fluid prism is hermetically sealed at *D* by a transparent, elastic membrane. This membrane remains completely tight, and no leaking of the fluid occurs for a long time.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

The sun prism, showing the sun's surface in its natural colors, allows observations of any duration to be carried out with full aperture of the objective, any spots and details of the penumbra as well as the

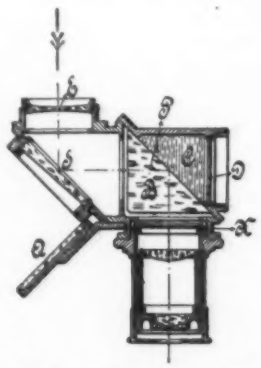
GENERAL PERSPECTIVE VIEW OF THE COLZI PRISM.

delicate shades of light of the sun's surface being seen with an extraordinary clearness and definition. The eyepiece is merely adjusted to a medium brightness; when altering the magnification by the use of more or less powerful eyepieces the convenient brightness is varied within permissible limits.

As in many instruments the ocular extension is not sufficiently long to combine the rays in the plane of the diaphragm of the eyepiece when inserting the sun prism, a simple concave lens of slight intensity should in such case be inserted in the path of the rays at *E*, increasing to some extent the focal length of the objective.

THE VISCOSITY OF MIXTURES OF OIL AND WATER.

As the viscosity of oil is very much greater than that of water, we should expect that any contamination of water with oil should noticeably raise the viscosity of the water. But according to experiments described by K. Beck, of Leipzig, in the Zeitschrift für Physikalische Chemie, Vol. lviii., the viscosity of water is scarcely increased when it is stirred with as much as 10 per cent of castor oil. From the behavior of colloids it is, on the other hand, evident that the viscosity of suspensions is much greater than that of the clear liquid, and this is confirmed by tests on the electrical conductivity of electrolytes, in which inert particles, like kieselguhr, are suspended; the resistance is augmented by the addition of these particles, which probably impede the ions in their migration. It would thus appear that the particles must be very near one another, and very small, if they are to affect the viscosity. Beck conducted his experiments on castor oil, which possesses a high viscosity. Taking the viscosity constant of water as unit, that of castor oil is 1,583 at 8 deg. C., 361 at 25 deg. C., and 124 at 40.5 deg. C. For his investigation Beck made use of Ostwald tubes, determining the number of seconds which a certain volume of the liquid took in passing through the tube. He prepared his suspension, first, by shaking the oil for half an hour with the water by machinery. He found it necessary to add a little cholesterol to prevent rapid settling. But even with suspensions containing 10 per cent of oil, the rate of flow was hardly influenced, the time rising from 152 seconds for pure water to 154 seconds for the mixture. More concentrated mixtures could not be experimented with, as they did not remain homogeneous. Beck, therefore, prepared emulsions by rubbing the oil and some gum arabic together in a mortar, and then adding the water. The addition of the gum was indispensable; but the gum itself increased the viscosity, and this effect had to be allowed for. In this manner he found that 5 parts of oil, 4 parts of gum, and 91 parts of water gave a viscosity constant of 2.72, while the gum alone gave 2.6. With 10 parts of oil to 4 parts of gum the constant rose to 3.2, this value being 20 per cent higher than the constant of the gum emulsion alone; with 20 parts of oil to 8 parts of gum and 72 parts of water, the constant was 12, being 40 per cent higher than the viscosity increase due to the gum. With higher percentages of oil, the experiments became too difficult. So far as the experiments go, the effect of the addition of oil to water on the internal friction would therefore appear to be small.—Engineering.



ARRANGEMENT OF MIRRORS AND FLUID OF THE COLZI SUN PRISM.

KINDS OF COAL PRODUCED IN THE UNITED STATES.

THE coal produced in the United States is reported by the United States Geological Survey as consisting of two classes—anthracite and bituminous. The bituminous product includes coal that may be classed as semianthracite, semibituminous, cannel, block, splint, and lignite or sub-bituminous. Almost the entire supply of anthracite comes from Pennsylvania, but 60,248 short tons were mined in Colorado in 1906.

Semianthracite was reported from Pennsylvania, Colorado, Indian Territory, Virginia, Montana, and Arkansas. Bituminous coal was produced in twenty-seven States and Territories in 1905, and in twenty-four in 1906, and forms by far the largest part of the total production. Semibituminous coal is mined in seventeen States and Territories, with West Virginia first, followed in order by Pennsylvania, Maryland, Illinois, Virginia, and Montana. Wyoming leads in the production of lignite or sub-bituminous coals, over 70 per cent of the production of the State being so classed. The so-called black lignites of the Rocky

Mountain States are entirely distinct from the real lignites, or brown coals. They are not lignites in chemical composition, in color, or in physical characteristics, and as they lie between the lignites, or brown coals, and the true bituminous coals, the term sub-bituminous has been adopted by the United States Geological Survey to designate them. In the production of this variety of coal Wyoming leads, Colorado is second, and New Mexico is third. A part of the product of California and Oregon should also be included under this head. The principal producers of true lignite are Texas and North Dakota.

The comparatively small production of cannel coal was obtained from nine States in 1905 and seven in 1906, of which Kentucky, Indiana, and West Virginia are the principal ones. West Virginia is also credited with nearly all the splint coal production, while Indiana is the leading producer of block coal.

THE BREATHING OF PLANTS.*

THE NECESSITY OF RESPIRATION TO ALL LIFE.

BY DR. C. STUART GAGER.

THERE is probably no scientific question concerning which erroneous notions are more widespread than the one regarding the difference between animals and plants. Ask the "average man" what this difference is and he will tell you, in the first place, that animals have motion while plants have not; or, if he is especially conservative, that animals have locomotion while plants have not; and second, that plant respiration is just the reverse of animal respiration. Animals, he says, "breathe-in oxygen and breathe-out carbon dioxide, while plants breathe-in carbon dioxide and breathe-out oxygen." It is with the latter of these "differences" that we are concerned in the following paragraphs.

By way of a gentle introduction it may be stated at once that plants breathe precisely as do animals, and, second, that they do not "breathe" at all. This seeming contradiction is explained when we remember that, as we think more accurately, our terms must be more carefully defined. In ordinary conversation "breathing" refers to the inspiration of fresh air into the lungs, and the expiration of the air that has been used. Obviously, plants have no lungs. We cannot *see* them breathe.

But this exchange of fresh and foul air is only incidental to respiration. Not all animals have lungs. Earthworms, insects, jelly-fish, and others may be mentioned as familiar examples of this fact. The real process, to which the physiologist applies the term respiration, has to do with the use that is made of the inspired air. From the lungs this air, in man for example, is taken up by the blood. Part of it the blood uses in its own respiration, the remainder it carries to all the tissues of the body, and delivers it to the individual protoplasmic units or cells. These cells take up the oxygen according to their needs, use it in performing their work, and return to the blood the carbon dioxide that results. Carried by the blood back to the lungs, the carbon dioxide is given off to the air in expiration. All of this is common knowledge. Respiration refers to that part of this process which goes on in the individual cells, while the term breathing may be to advantage restricted to the work of the lungs. Respiration, then, is a cell-process, and every organism that is alive and every living cell of that organism must respire. All plants are built up of cells, some of which are alive and some not. All the living cells of plants respire, just as truly as do those of animals.

It is difficult to demonstrate the cell processes, but the outward manifestation of them—the absorption of oxygen and the evolution of carbon dioxide—is very easily shown.

Into each of six fruit jars place portions of the different parts of plants as follows: into the first fresh roots, into the second stems, into the third leaves, into the fourth flowers, into the fifth germinating seeds, and into the sixth nothing. A lighted candle will continue to burn when placed in any of the jars. Seal them all air tight. If, at the end of twelve hours, a lighted candle is thrust into each of the jars, it will be extinguished in each of the first five, but will continue to burn as usual in the sixth. This shows us that the air in the five jars has become poorer in oxygen, while that in the sixth jar is apparently unchanged. If now we pour clear lime-water into each of these jars, the water will become milky in each of the first five, but will remain clear in the sixth. This indicates that in the first five the amount of carbon dioxide has been increased, but not so in the sixth.

Since the only difference between the first five jars and the sixth is the presence, in the former, of parts of living plants, we must conclude that the change in the air is due to the vital activities of the roots, stems, leaves, flowers, and seeds. But an absorption of oxygen and an evolution of carbon dioxide, we have learned, is the outward indication of the cell process called respiration. In this, and in many other ways, it may be shown that plants respire.

It will be seen here that plant respiration is not confined to the leaves. Nothing can be more misleading than to speak of leaves as the "lungs of plants." If any comparison at all is to be made they could better be called the stomachs of plants, for in them processes of digestion go on with as much, if not more, vigor than does respiration. Moreover many kinds of plants such as bacteria, algæ, fungi, liverworts, and others, have no leaves, but respiration goes on in them notwithstanding, and trees in winter, after all the leaves have been dropped, continue still to respire.

No vital activity is as important as respiration. Food may be supplied, water and air may be abundant, but without respiration life is impossible. The power to respire marks the chief difference between the living and the non-living. In the realm of living things it is universal and incessant. It is always, in all essentials, the same process, whether in plants or in animals. The failure to recognize this fact gave rise in the latter half of the last century to the doctrine of vital dualism. Because of the supposed difference between animal and plant respiration, it was argued that there were two kinds of life. A clearer understanding of the vital processes of animals and plants, however, has taught us that life is one. No clearly defined line can be drawn between the two kingdoms. As great differences exist between certain animals, and between certain plants, as are found between animals and plants. But the process of respiration is everywhere the same. Even dry seeds respire.

In regard to the amount and rate of respiration the supposed difference between animals and plants breaks down. Under favorable conditions the process may be even more active in plants than in animals. In man the carbon dioxide produced in twenty-four hours equals about 1.2 per cent of the body weight, but in some of the molds the amount has been found to equal 6 per cent of the dry weight of the plant. Bulk for bulk, very active bacteria may consume oxygen 200 times more rapidly than man. In both kingdoms respiration is accompanied by an evolution of heat.

In plants, as in animals, the rate of respiration varies with the age of the organism, and with external conditions. Breathing, which is the expression of respiration in man, is most rapid with infants, and decreases with the approach of old age. So it is with plants, for germinating seeds and young seedlings respire more rapidly than mature plants. Increase of work is accompanied with increase of respiration in animals; in trees, also, the process is more vigorous in the spring, during the work of bud-opening and the putting forth of new leaves and flowers. Under bodily pain or mental excitement we breathe more rapidly, so also does a plant that has been cut, or otherwise injured, or subjected to any stimulus, as, for example, violent shaking. A thermometer placed in a dish of cut onions, for example, will indicate the existence of a fever (due to the wounding of the tissue), just as surely as if placed in the mouth of a typhoid patient.

This question is far from having a merely academic interest. Practices that have been in vogue since man first began to till the soil, and that must be continued as long as agriculture is carried on, depend, in part, upon the respiratory function of plants. I refer to plowing the soil and hoeing the crops. It is not alone to get the soil into a suitable physical condition that it is broken up by the farmer. The roots and other underground parts must have air to respire, just as much as the parts above ground, but if the soil is hard and compact this need is but poorly met. The plow, the spade, and the hoe facilitate the thorough aeration of the ground. For the same reason it is desirable frequently to loosen the surface of the soil in flower pots, and this, in part, is why flower pots are made of porous material.

Emphasis has been laid upon the fact that only living things respire. While this is perfectly true of the physiological process, it is not true of the mechanical act which may be designated as breathing. The entire soil area of the globe is subject to great inspirations of atmospheric air, and expirations of the gases resulting from life processes underground. This process is necessary to the healthful respiration of soil-organisms, and of the underground portions of all land plants. Without it land vegetation would perish and the world would become a desert.

The "breathing" or aeration of the soil is accomplished in a variety of ways. In all regions where it has a depth of fifty feet or more, the ground at a certain distance below the surface is soaked with water, so that all the spaces between the soil particles are completely filled. The upper surface of this moisture is called the water-table, and above it the soil contains only capillary water. The interspaces between the soil particles are filled with air, and only the surfaces of the grains are wet. The level of water in a well marks the level of the water-table in the soil. In the spring, and in other wet seasons, this water-level stands at a greater height than in periods of dry weather, and, as it falls, air from above ground enters the soil. When the water-table rises, gases are forced out.

The gradual heating of the soil during the day causes the soil-air to flow out, while the nocturnal cooling is accompanied by a current in the opposite direction. Wind blowing over the surface causes an outflow, the calm that follows an inflow. Thus the great soil-breathing goes constantly on.

It is in this way that fresh air is continually supplied, not only to roots, but also to the soil-bacteria, some of which are able to convert the nitrogen of the air into a form available to other plants, others of which are able to convert the ammonium-compounds into nitrates and the nitrates into nitrites, in which form they may be utilized by higher plants. For bacteria respire as truly as ourselves.

The question as to what becomes of all the roots, and why the soil never becomes clogged, may possibly never have occurred to some of us. Several causes explain this, one of which is the process of putrefaction, which is explained by the respiration of a certain kind of microscopic plants. These plants are called *anaerobes*, because they normally respire anaerobically, that is, without the presence of free external oxygen. Some of them are unable to respire at all if free oxygen surrounds them. If, therefore, the aeration of the soil is interfered with, these plants find ideal conditions for their growth and activity, and the soil becomes "sour," and unfit for crops.

From the above considerations it becomes clear that agriculture, the most fundamental of all human industries, depends for its successful pursuit upon practices whose whyfore is found in the fact that plants respire.

But husbandry is not the only point where the respiration of plants touches our daily lives. Upon the respiration of the yeast-plant depends the enormous brewing industry of our own and other countries, and upon the respiration of another yeast-plant we are dependent for the lightness of our daily bread, for the fermentation involved in "raising" dough is a kind of respiration. The difference between a "good" and a "bad" cigar is partly attributable to a similar cause, for the difference is connected with the curing of the tobacco, and this process involves the respiration of bacteria. So, too, does the tanning of hides, and the separation of flax and hemp fibers from the plants that produce them.

Cold storage warehouses and refrigerator cars are made necessary, in part, because of the respiration and universal presence of myriads of microscopic plants that float in the air, for, whereas heat accelerates respiration, cold retards it. The turning rancid of butter, the souring of milk, the formation of vinegar from cider, are all dependent upon the same process. If plants did not respire, canned fruits and meat would seldom spoil. That a hen's egg is a miniature botanical garden is a bit of that truth that is stranger than fiction. The ovophytic flora enters the egg in the body of the fowl, before the formation of the shell, and the respiration of the entombed plant is one reason why eggs will not always remain "strictly fresh," and why cold storage will prolong the period of their freshness.

Someone may raise the question of the value of plants in the sick room. It may be at once recognized that they have the same kind of an effect on the air of a room that a person or a burning gas jet would have, though possibly not to the same degree. If the plants were abundantly supplied with green leaves, and were well exposed, even to bright diffused sunlight, they would supply an insignificant amount of oxygen to the air. But at the same time they would be sources of carbon dioxide. And when we recall that the "plants" in a sick room are usually cut flowers, often not over fresh, and that flowers respire more vigorously than any other part of a plant except germinating seeds, we do not need to be further enlightened as to their power of purifying the air. Our scientific knowledge, however, should not, as it is often liable to do, get the better of our "sense uncommon, men call common sense," for the brightness and cheer that flowers bring to the sick need never be sacrificed for fear of their evil effects upon the air.

* From a lecture delivered at the New York Botanical Garden, October 27, 1906, and reported in the Journal of the New York Botanical Garden, July, 1907.

ENGINEERING NOTES.

A method of shaft sinking has been tried in France in which cement slurry is forced through boreholes into soft fissured strata in order to form a wall of concrete within which sinking can be performed.

A new boiler-cleaning compound is reported from Mexico. It is made wholly from vegetable substances, and is said to remove scale from boiler tubes, while causing no injury to the tubes or boiler shell.

What is considered to be the deepest coal bore in Great Britain has just been completed. The bore, which was sunk on a field near Cameronbridge, reached the extraordinary depth of 4,534 feet, before the objective, mountain limestone, was reached.

It is now demonstrated, according to the Engineer, that the reason copper and iron will not alloy is on account of the carbon that the iron absorbs in melting. If the iron and copper be melted together in a clay crucible, so that no carbon can be taken up, the resulting alloy is perfectly homogeneous and free from any separated nodules.

A company has been formed for the construction of a tramway from Annecy, *via* St. Julien, to Geneva. Electric power will be used if it is found practicable to utilize the waters of the Rhone. The Journal des Transports states that the only difficulty will be the construction of a bridge over the torrent of Usses. The cost of construction is estimated at $560,000, and the line will be about 25 miles in length.

An investigation has recently been made to determine the absolute sensitiveness of the ear. By experiments with a telephone and alternating currents of frequencies 250 and 500 per second determinate pressure variations were produced at the ear. The experiments lead to the conclusion that the normal ear can respond to a pressure variation of about four ten-millionths of a millimeter of mercury.

The Boletin Oficial, of Argentine, contains decrees approving the plans of the Oeste de Buenos Aires Railway Company's line from Monte Nievas to Vitorica, the plans of the Compañía General de Ferrocarriles en la Provincia de Buenos Aires for a central station at Buenos Aires, and the plans of the Buenos Aires Pacific Railway Company for a station on their branch line from Perdenera to La Paz.

The details of the two battleships to be built at Yokosuka and Kure for the Japanese navy are reported to be: 20,800 tons, 20 knots, 20,000 horsepower, ten 12-inch guns, twenty-four 15-centimeter quick-firers, twelve-pounders, and 47-millimeter guns, eight torpedo tubes—four in water and four above. The cost of the vessels is estimated at over ten million yen ($5,000,000) each. The construction of these battleships will probably be started early next year.

The French Admiralty announce that during 1908 only ten torpedo boats and five submarines will be laid down, the Admiralty being determined to concentrate their efforts on the completion of the six battleships provided for in the programme of 1906. These vessels are not expected to be ready before the beginning of 1911. There are already under construction thirty-two torpedo-boat destroyers and fifty-one submarines.

The "Dreadnought" will shortly be docked to have another set of propellers fitted. After she had completed her steam trials there was a considerable falling off in her speed. It was thought that the deficiency could be met by the provision of a new set of propellers, but when these were fitted, the subsequent tests showed that her speed was still less than that attained on the original trials. Now a third set of propellers is to be fitted, in the hope of regaining the lost speed.

According to Poor's Manual, 815,800,000 passengers were carried on American railroads during 1906. Twenty-five billion, eight hundred and forty-two million passenger miles were covered, bringing a revenue of $521,000,000, or, at the rate of 64 cents per passenger, 2.01 cents per passenger-mile, and an average trip per passenger of 31.7 miles. The freight movement involved 1,610,000,000 tons and 216,654,000,000 ton-miles, and the corresponding revenue was $1,660,000,000, which figures out at 103 cents per ton, 0.766 cent per ton-mile, and an average movement of 135 miles. The total capital stock on 218,433 miles amounted to $7,106,400,000, or $32,540 per mile; the bonded indebtedness was $7,851,000,000, or $35,948 per mile; total, including also equipment obligations, $15,593,550,000, or $71,388 per mile.

The absence of efficient means of protecting the underwater parts of a battleship from submarine attack has prompted the British Admiralty to decide upon experiments in this direction, which will involve the sacrifice of a submarine boat. In the earlier days of submarine design the naval authorities devised a special type of spar torpedo which was carried upon a speedy torpedo boat. On the rising of a submarine to the surface this boat was to steam toward it and explode the torpedo in proximity to it. It was expected that the concussion would severely injure the submarine. It is now realized that any such protective effort is useless, owing to the impossibility of the torpedo boat gaining the spot of appearance within a short time. It is now, however, held among the British naval authorities that the only means of rendering a submarine boat *hors de combat* is to upset its equilibrium, by setting up an extensive disturbance in close proximity thereto. The submarine to be used for the experiment is the first of the Holland type that was built for the British navy, and the investigations will be undertaken by the Torpedo School at Portsmouth. Mines of various explosive capacity will be fired close to the submarine, when it is in a variety of positions, such as submerged, awash, and above water.

SCIENCE NOTES.

Red light is reported to have given good results in the treatment of skin diseases. The light was obtained by passing light through a screen, made of two sheets of glass containing between them a solution of eosine. The results given were good in cases of superficial lesions, of impetigo, and of acute eczema. In the treatment of wounds of various kinds, the red light exerts a stimulating and beneficial effect, as shown by the red color of the granulations and the rapidity of healing. Although exercising a very active biological influence, the red light is not very bactericidal.

People who live on the seashore have always recognized that there is danger in eating mussels. In France recently thirteen people were ill, and two of them died, as a result of eating mussels. As the result of an inquiry following this, it has been found that in the edible mussel, *Mytilus edulis*, there is at times a poison, which in its action upon rabbits, guinea pigs, frogs, and mice, produces similar toxic effects to those which follow the administration of curare. This poison, which is not affected by cooking, exists in the liver of the mussel; which organ is large, very dark, and very friable. Mussels from the district where the poisoning occurred were found to be toxic on May 26 and June 11, were free from it later; in fact, the toxicity had disappeared by July 8. Other animals taken from the same basin, the fish, eels, and sea urchins, were found to be not toxic. The star fish, however, showed the same toxicity as the mussels had and this toxicity likewise had become much diminished by the 8th of July. The cause of the toxicity remains still unexplained. It may be that the mussels and star fish derived it from feeding in a contaminated basin. It might also be caused by a disease of the mussels, in the course of which the liver of these animals became toxic.

An element termed "coronium" is said to have been found in the gases from the Solfatara of Pozzuoli, while the gases from Vesuvian fumaroles are stated to give spectra containing lines not coinciding with any important line in the spectra of neon or helium. Hence an investigation has been made by Mr. J. E. Coates to determine whether systematic quantitative fractionation of large quantities of air would yield any constituent lighter than helium. A second object of the research was to redetermine by fractionation the amount of free hydrogen in air. In the experiments about 73,500 liters of air were concentrated in an air-liquefying apparatus, and the non-liquefying portion further fractionated by treating 70 to 80 liters at a time in glass bulbs immersed in liquid air boiling under reduced pressure, the volume being thus gradually reduced to 4,700 cubic centimeters. This residue was then sub-divided into further fractions by treatment with charcoal at temperatures of —110 deg. C. to —190 deg. C., and a final fractionation effected by means of liquid air at a temperature of about —205 deg. C. The various fractions were examined spectroscopically, and it was found that there were no unknown lines in the spectrum of the lightest portion of air. As regards the amount of hydrogen, previous determinations by M. Gautier gave 19.5 volumes in 100,000, while Lord Rayleigh estimated the proportion at not more than three parts, and Sir James Dewar at not more than one part in 100,000. The amounts separated by Mr. Coates, however, were very much less, and he concludes that the proportion of free hydrogen in air is only about one volume in 1½ millions.

In a communication to the French Association for the Advancement of Sciences, Pierre Delbet recently reported the results of a number of experiments made upon dogs to determine the effects of the entrance of air into the veins. He found that the air exerts no poisonous action upon the blood; but its action is purely mechanical; it only produces accidents by reason of the manner in which it is introduced. It is absorbed by the blood with facility, and is carried from the heart into the lung, which becomes, from this point of view, an organ of excretion. The important part to consider is the rapidity with which it is introduced into the veins. We may, in fact, inject as much air as we wish, provided it is not introduced too rapidly. In the dog, the limit is 5 cubic centimeters of air, per minute, to each 5 kilogrammes of body weight. It is the air that remains unabsorbed and free in the blood, which becomes dangerous, and it is not the distention of the right chambers of the heart which is the mechanism of death. The respiration stops before the heart ceases to beat. Artificial respiration is of no avail. It is incapable, in case of death, to resuscitate the animal. He was able to introduce 80 cubic centimeters of air, in eight minutes, in a dog weighing 8 kilogrammes. The lung acts as a regulator. The respiration, instead of becoming slower, increases in rapidity. It occurred to Delbet to substitute, for the air, oxygen mingled with the vapor of chloroform; but we found that it was impossible, even using three liters of oxygen and chloroform vapor, to cause anæsthesia or produce sleep. He suggests that the introduction of oxygen into the veins might be useful in the treatment of cases of death from chloroform. Perhaps it might also be beneficial to study its rôle, when introduced into the veins, in the treatment of various infections.—Therapeutical Notes.

TRADE NOTES AND FORMULÆ.

To attach paper to metal and produce strong adherence, as desired for cards and labels, a small quantity of carbonate of potash should be added to the paste.

Cement for Fastening Precious Stones.—This is a mixture of one part each of lead dross and powdered chalk and three parts of graphite; three parts of linseed oil are added and the whole thoroughly mixed.

Liquid Glue.—A very good liquid glue is produced by adding to ordinary glue its volume of vinegar and the fourth of a part of alcohol. A little alum may also be added as a preservative.

Cement for Shell and Horn.—Five hundred parts of glue are dissolved on the water bath with 125 parts of alcohol; 10 parts of pulverized alum are added and the whole mingled on the fire. If the cement is too thick, water is to be added.

Translucent Cement for Repairing Glass.—75 parts by weight of caoutchouc are distilled in 60 parts of chloroform, 15 parts of mastic added, and the whole left to macerate for a week. If a more elastic cement is desired, the proportion of caoutchouc is increased.

Gold leaf, to attach permanently to paper or cardboard without discoloration by the adhesive striking through. Dissolve finely shredded isinglass in a little water, at moderate temperature, which must not be allowed to reach the boiling point. Add as much nitric acid by weight as of isinglass.

Strong Natural Glue.—The large snails found in gardens have a vesicle filled with a white, fatty, gelatinous substance, which, applied between two divided parts of an object, such as broken pieces of porcelain, glass, or stone, unites them solidly, provided the broken pieces are brought closely in contact. This substance will replace ordinary glue advantageously, if time is allowed for thoroughly drying.

Universal Cement.—A mixture is formed of:

Gum arabic	100 parts.
Starch	75 parts.
White sugar	21 parts.
Camphor	4 parts.

Dissolve the gum arabic in a little water; dissolve the starch also in a little water; mix the whole, add the sugar and camphor, put on the water bath, and boil until a paste is formed, but rather thin, because cooling will thicken it.

Gold Leaf, Imitation, Alloys for.—

	Deep Gold.	Pure Gold.	Pale Gold.
Copper	84.5	78	76
Zinc	15.5	22	14
	Deep Gold.	Deep Gold.	Gold.
Copper	91	86	83
Zinc	9	14	17
	(Reddish)	(Dark yellow)	(Bright yellow)

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